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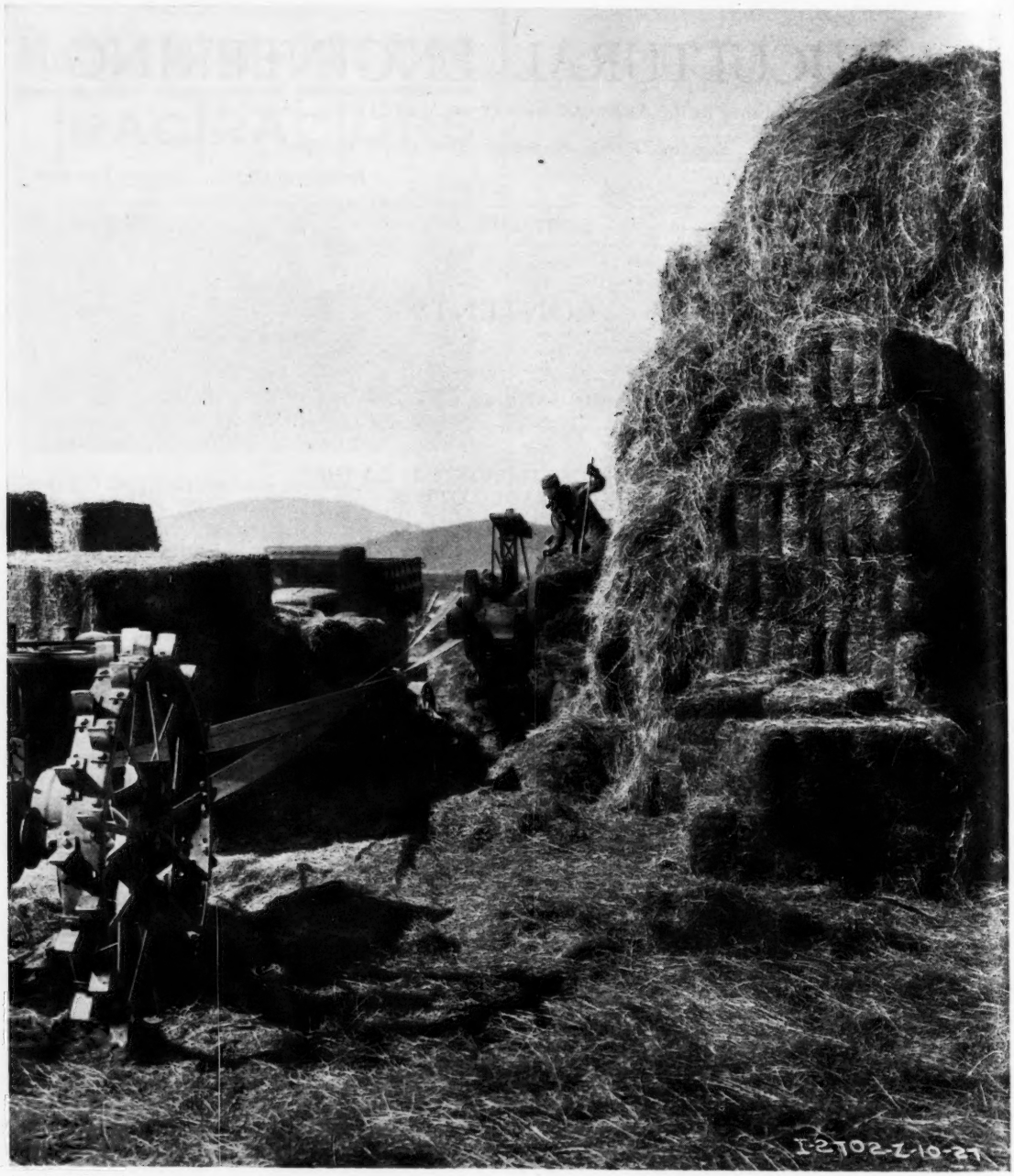


The Farmer's Cellulose Mountain

BALED by-product straw is a compressed packaged cellulose which grain farmers are ready to deliver to factories whenever industry is in a position to use it in ways which justify a price at the farm higher than its worth on the farm. Its finely divided condition is a possible advantage for some processing operations. It offers a wide range of characteristics according to type and variety. It is not highly perishable. Its cost as a raw material would be a small item if it were found especially suitable for the production of some high-quality, high-yield fibrous or chemical product. Here is one case where the material, the farm equipment manufacturer, and the farmer are ready and waiting for whatever market chemists, chemical engineers, and fiber-processing industries may be able to develop.

AGRICULTURAL ENGINEERING

VOL 19, NO 9 EDITORIALS SEPTEMBER 1938

Cotton Gin Precedent

ELI WHITNEY'S contribution to cotton production is probably an assumed precedent for some of the popular fear that someone has found or is about to find the secret of laborless mechanical cotton picking.

The cotton gin, however, offers no genuine precedent as to the mechanical probability of a corresponding revolution in picking methods. The problems involved are not comparable. If the South had been producing dog hair instead of cotton, Whitney might as readily have developed a gin to comb the loose hair from hounds brought to the machine. The operation of selecting and catching just the right canines from a pack, however, would probably have long remained largely a manual operation, guided by human discretion, as has cotton picking.

Ginning is essentially a stationary power operation conducted in a building on material brought to the machine, the material being of two distinct types readily susceptible to mechanical handling and separation. Cotton picking, however, involves the selection and separation of mature bolls with a minimum of injury to the living plant and immature bolls. It requires a selectivity based on color or texture. It necessitates movement of the picking agency to the material, and either considerable dexterity of individual movement or a complicated uniform movement of the picking mechanism in the plant space to gather high, low, inside, and outside bolls of low individual unit value. To meet all of these and numerous other mechanical, biological, economic, and human problems with one machine is difficult, as evidenced by the rate of progress to date.

We offer this comparison neither to belittle the progress made in ginning equipment, nor to deny the possibility of a successful mechanical cotton picker. We simply wish to emphasize the realistic view of the problem shown in papers on the subject in this issue of AGRICULTURAL ENGINEERING.

If the cotton gin offers any reasonable precedent for the mechanical picker, it is probably in the matter of the social and economic influence a highly successful picker might exert. Suppose that a picker is developed which will reduce the labor of picking by the same percentage as the labor of separating the seed was reduced by mechanical ginning. History does not reveal that the gin created any great depression in the cotton industry, or threw any army of specialized laborers into helpless confusion. Low-labor and low-cost cotton picking would require some readjustment, but it would put cotton in a much better competitive position among the fiber and vegetable oil industries. It would give the workers it could use an opportunity to work more productively than is possible in the hand picking of cotton, and to be better customers of the people who are customers of the cotton industry.

Calamity criers of the cotton fields see a sheep in wolf's clothing. They might better be opportunists and sell it a complete new wardrobe, from cotton duck to rayon and cellophane.

Depreciation of Farm Equipment

RECENTLY we were asked point blank, by the representative of a practical farm paper, how much poor care added to the depreciation of farm equipment. Obviously, we could not tell him very definitely, although agricultural engineers should have that information if anyone would.

We all know or suspect that, in general, a binder or a tractor may depreciate more rapidly while standing in a fence corner than when on a dry floor and surrounded by four walls and a roof. But who can say how much exposure contributes to depreciation?

Rust damage, for example, depends largely on the individual part or parts affected. On the rough surface of a heavy casting it may be negligible. On the share and moldboard of a plow to be used in gumbo soil it means a scouring chore before effective work can be done. On a wire spoke, strength is the important factor influenced. In a metal container depth or rate of penetration in any one spot may determine rust damage. On an adjusting nut rust will cause one kind of trouble; on the glass polish of an engine cylinder, another. Rust trouble may occur not only at the point where the rust originates, but at other places to which it gets moved, as in a fuel line. It may influence not only the adjustment, operation, and life of equipment, but the quality of product and even the sales resistance of the farmer's customers.

Rust is only one result of poor housing. Absorption and accumulation of moisture may interfere with the operation of electrical equipment, and wood and fabric parts easily lose strength through decay. Lack of housing, too, is only one factor in depreciation. Repair, adjustment, and lubrication are others.

Farm equipment is made up of numerous parts with separate and distinct purposes, varying in importance of strength, fit, tightness, ease and correctness of adjustment, cleanliness, lubrication, and appearance; subject to depreciation from different causes; and with widely varying influence on timeliness of operation and net income. An exhaustive study to accurately determine resultant depreciation costs would be prohibitively expensive, if not impossible. Furthermore, every farmer who has ever scoured a plow, wired together a harness, struggled with a rusted bolt, bought new parts, waited at the local shop for service, or stepped on a rusty nail during the rush of spring planting or fall harvest, knows that depreciation costs him money. The main question is not how much it costs him, but how to break the operating habits by which he imposes on himself the needless tax of excessive depreciation.

Possibly farm equipment in the future may be weatherproofed better than it is at present. From a research angle, there would seem to be a possibility of working out ways of making it easier for farmers to protect their equipment from depreciation. And from the standpoint of agricultural engineering extension the problem seems to be one of getting more farmers actually started in taking simple steps which they know would save them money.

Engineered Living Conditions

UNCLE SAM'S Bureau of the Census is a veteran observer of life and living conditions in the United States. The depression-born tumult and shouting against mechanized civilization and labor-saving machinery leaves it unmoved. For lack of a better index, it still measures living conditions in terms of modern improvements and conveniences, the engineered accessories of good living.

In a recent report, the Bureau shows an improvement between 1930 and 1938 in farm living conditions in terms of farm tractors, motor trucks, automobiles, electric service, radios, telephones, housing space, running water, and other indications.

These are all products and services made possible or greatly improved by engineering. We are pleased to note that they include efficient production equipment as well as living conveniences, and such a characteristic product of agricultural engineering as the farm tractor. This is statistically authoritative corroboration of a principle agricultural engineers have been advocating for a long time, namely, efficient production equipment, efficiently used, can and does improve farm living conditions.

While the mere presence of tractors on farms is not in itself evidence of improved living conditions, the 100 per cent increase from 1930 to 1938, in the number of farms having tractors, indicates substantially increased farm acceptance of the tractor as a means of improving farm living conditions. It is further indication of improvement in the tractor itself, and in its utilization. It gives encouragement to agricultural engineers to continue their work of improving the facilities of farm life and production, together with the utilization of these facilities, wherever possible.

The Engineering Inherent in Agriculture

PERHAPS some new wording might further clarify the position of agricultural engineers, as to the extent to which they apply the older technical branches of engineering to agriculture, and the extent to which they deal with the engineering inherent in agriculture.

Commercial opportunity and public convenience are the motivating forces which, directly or indirectly, support engineering effort to make practical use of scientific facts.

Types of opportunity and conveniences influence the type groups of scientific facts which find expression in engineering principles, application data, equipment, and methods. Only the science which a particular technical branch of engineering finds useful gets into its handbooks and daily practices. Civil engineers use one group of scientific facts, electrical engineers another, with little enough duplication to avoid competition in the same field of engineering service. Much of physics, the science most used by engineers, remains unused by many engineers because they have not yet found applications for it in connection with the commercial opportunities and public conveniences which support their work.

The engineering inherent in agriculture might be defined as the scientific facts potentially useful to engineers in improving the commercial opportunities and conveniences of farm production and farm living.

To the extent that these truths of science have already been used by other engineers in ways also useful to agricultural engineers, these uses may well be borrowed, with credit, from the older branches of engineering.

But the purposes and conditions in agriculture are so different from those met in mining, transportation, public works, and urban industries that much of the engineering used in the latter is of little or no value for use in agriculture. And likewise the unique purposes and conditions of agriculture give a high potential agricultural engineering usefulness to scientific truths not used in other branches of engineering. Here is where agricultural engineers find their greatest problems and opportunity for service; and where the older branches of engineering fall short of technical adequacy to cope with the big problems and opportunities of agricultural engineering.

The fine minds which have led progress in the fundamental branches of engineering could undoubtedly broaden their science base to cover agricultural problems in their respective fields. However, they have not, in general, found it economically profitable or professionally feasible to do so in combination with their organization and training to meet the distinctly different problems of engineering for urban purposes or of industries other than agriculture.

In terms of the science utilized, therefore, agricultural engineering is not primarily the older branches of engineering put to work in and for agriculture. It is rather the development of a new engineering, to meet the unique requirements of agriculture, from science hitherto not used by engineers, or not used in the same ways, combinations, and magnitudes as are found useful in agricultural engineering.

Agricultural engineers acknowledge their debt to the older branches of engineering for fundamental training and a sound foundation for specialization. The frontier of progress in that specialization is in the utilization of an overlapping but distinct range of science, the engineering inherent in agriculture.

"Underwriters' Laboratories, Inc.," Please!

To the Editor:

A representative of the National Electrical Manufacturers Association recently called our attention to certain publications of college and university agricultural experiment stations in which instructions are given on the selection, operation, and care of all kinds of household electrical equipment. It was stated that in almost every case the bulletins make reference to "equipment which bears the seal of approval of the National Board of Fire Underwriters," whereas it was evident that "Underwriters' Laboratories, Inc.," was intended.

I have been informed by Mr. Truman E. Hienton of Purdue University, that the publication of an article in AGRICULTURAL ENGINEERING calling attention to this error, will reach the authors of these college and university publications.

Although Underwriters' Laboratories, Inc., is sponsored by the National Board of Fire Underwriters, the approval of electrical equipment is directly under the jurisdiction of the Laboratories, and equipment which is tested and found safe bears the Underwriters' Laboratories, Inc., marking rather than the marking of the National Board of Fire Underwriters. The purchaser of equipment knows that it is standard through the label or listing by Underwriters' Laboratories, Inc.

VICTOR H. TOUSLEY
Secretary-Treasurer
International Association of Electrical Inspectors
Chicago, Illinois

The Evolution of the Mechanical Cotton Harvester

By E. A. Johnston

UP UNTIL a little more than a century ago all agricultural operations were performed manually. The invention of the reaper was the beginning of the mechanization of farming, and that mechanization has emancipated the human race from the wanton waste of all its energy in the age-old battle for food.

In 1790 the labor of nineteen American farmers was required to feed and clothe one city dweller. Ninety-five per cent of our population lived on farms, five per cent in cities. Today, actually seventy-five per cent, or 98,000,000 of our people, live in cities and are fed and clothed by the other twenty-five per cent, or 32,000,000, living on farms. This great transformation was directly due to mechanization of farming, and with it and because of it has come about our nation's social and economic progress.

Cotton growing is the least mechanized major division of agriculture. While to some extent modern machines are used in planting and cultivating cotton, yet this, our greatest crop and largest export item, is still harvested by hand. Every year in the South millions of human hands pick cotton in the same slow, tedious, backbreaking manner as was used thousands of years ago in the valley of the Nile when the Pharaohs reigned.

The idea of alleviating this situation is not new. Our patent office files show that as early as the year 1850, or 88 years ago, a patent was issued on a mechanical cotton picker.

Since then hundreds of patents on various devices intended to aid the manual cotton picker, or to supplant him, have been issued.

At frequent intervals during the past forty or more years, some wonderful new mechanical cotton harvester has been announced, which promised to revolutionize the production of cotton and create a major economic and social disturbance in the cotton-producing areas.

The publicity about these machines implied that they were some sort of mechanical robot equipped with brains and eyes which would enable them to select only the mature cotton and leave the immature cotton, would not destroy the immature bolls, would gather the cotton without gathering leaves, grass, or trash, and would greatly reduce the cost of producing cotton. After many years of investigation and intensive research in connection with the development of mechanical cotton pickers, there are still many problems unsolved and much to be accomplished.

Since inventors and engineers have worked for nearly 100 years at the problem of harvesting cotton mechanically, and yet no such machine has ever been marketed on a commercial scale, it is at once apparent what a difficult problem it is. Only those who have shared in this work can fully appreciate the difficulties.

The International Harvester Company itself has been working at the problem for more than thirty years. Each year we have profited by field experiences, and improvements and refinements have been made. This development has been evolutionary, and out of this long effort has come a machine which operated to the satisfaction of plantation owners in numerous tests last year.

You will be interested to know just what are some of the difficulties encountered, and why the perfection of a mechanical cotton harvester has come so slowly.

To begin with, the problem is in a way similar to attempting to make a machine to pick strawberries. Berries do not all ripen at one time, and likewise cotton does not all mature at one time. Only the mature fruit must be selected and harvested in either case, and leave the plants and the immature fruit undamaged.

In addition to this, there are many other difficulties presented by variations in types of cotton plants, and also variations in habits of growth of the same type of plant from season to season and in different kinds of soil. The height of the plants and their spread of branches varies so greatly that it offers quite a handicap.

Just last season in the Delta region, due to excessive and frequent rainfall, the gins were unable to operate on account of the wet condition of the cotton, and hence picking was delayed for many weeks, and during this period of delay, not only did the cotton that had opened and had been waiting to be harvested deteriorate due to weathering, but abnormal growths of foliage occurred. The summer rains had already produced such a rank abnormal growth that the spread of branches made the cotton rows virtually indiscernible, and it was difficult even to walk through some fields. The plants were loaded with open dead-ripe cotton, and at the same time there was a heavy second growth in bloom and with green bolls forming. This condition made mechanical harvesting extremely difficult until frosts killed this green second growth.

THIS FIELD SCENE OF THE 1937 INTERNATIONAL HARVESTER COMPANY'S COTTON HARVESTER SHOWS THE FRONT VIEW OF THE PICKER AND A ROW OF COTTON BEING PICKED ENTERING THE PICKING MECHANISM AT RIGHT OF AND BELOW THE DRIVER. PICKED COTTON IS DISCHARGED THROUGH A PIPE SPOUT INTO BAGS ON THE PLATFORM AT THE FRONT OF THE PICKER

An address as the 1938 recipient of the Cyrus Hall McCormick Gold Medal awarded by the American Society of Agricultural Engineers, and delivered before the annual meeting of the Society, at Asilomar, Pacific Grove, Calif., June 29, 1938.

Author: Vice-president in charge of engineering, International Harvester Co.

Another great handicap in the development of a mechanical cotton harvester is the fact that the time for testing such a machine during each harvest is limited, and as a result a whole year must elapse before mechanical alterations can be tried.

Apart from the field problems that occur from varying soil and weather conditions, the following basic requisites of a successful mechanical cotton picker are difficult to achieve:

1 It must harvest a high percentage of the mature cotton, with a minimum dropped on the ground.

2 It must not seriously damage the plants or the immature cotton bolls.

3 It must not seriously damage the cotton, so that the highest possible grade of ginned cotton may be obtained.

4 It must have sufficient capacity to make its operation profitable, as compared with hand picking.

5 It must gather as clean a sample as possible, with a minimum amount of leaves, stems, hulls, weeds, etc., entrained in the lint.

6 It must be mechanically sound in design so that it will provide satisfactory, consistent, and dependable operation, and must be simple enough that both the operation and the ordinary servicing of the picker can be done by farm labor.

7 In order to afford most profitable utilization, the mechanical harvester preferably should be an attachment for a farm tractor rather than a self-propelled machine, so that the tractor may be available for other purposes.

The difficulty of meeting these basic functional requirements explains why the hundreds of early attempts either to aid the hand picker, or to produce a mechanical harvester, failed for one reason or another. Claw-fingered gloves proved a handicap rather than an aid to the hand picker. Manually operated devices of all kinds, intended to make hand picking easier and faster, actually did the opposite.

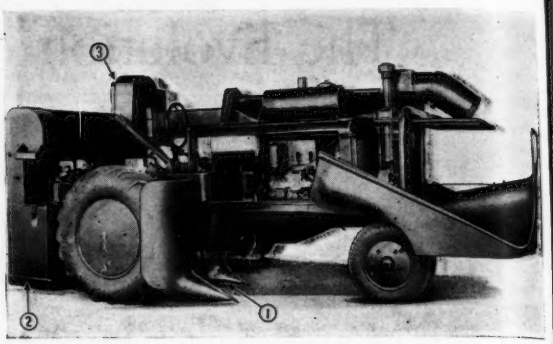
Early machines with either vertical or horizontal spiked drums or disks not only injured the plants by the raking action of such mechanisms, but gathered very little of the cotton, and dropped on the ground most of that which was thus clawed out of the bolls.

Machines having rotary brushes likewise were failures, as were machines which dragged chains bearing hooks through the plants.

Pneumatic pickers of either the pressure or suction type have failed because of the excessive power required for their operation; and the great amount of dirt, leaves, and trash sucked in with the cotton by vacuum type machines, have made them unsatisfactory. Still further, most pneumatic pickers have required manually controlled and directed suction tubes which must contact the individual cotton bolls, and this has proved to be slower than bare hands in gathering the crop.

A careful analysis of the problem and our early experience indicated that a rotary spindle type of picker was the most promising, and hence our company's efforts have been intensively centered on the development of a harvester of this type.

It has been known for many years that cotton can be removed from the bolls by revolving spindles, but to develop a spindle that will gather the lint effectively and not injure the plant or immature bolls is not easy, and to incorporate such spindles in a machine that will gather a high percentage of the cotton, will drop a minimum amount on the ground, will gather a minimum amount of extraneous matter with the cotton and produce a sample which compares favorably with hand-picked cotton, is an extremely difficult problem.



RIGHT-HAND VIEW OF COTTON HARVESTER SHOWING (1) WHERE COTTON PLANTS ENTER, AND (2) SHOWING CHAMBER FOR DOFFERS WHICH STRIP COTTON FROM SPINDLES. THE COTTON IS THEN CARRIED BY ELEVATING CONVEYOR TO CLEANER

Cotton has a high affinity for nearly everything with which it comes in contact, and consequently it is unreasonable to expect any mechanical picking device to gather the cotton entirely free from some leaves and other extraneous matter.

With mechanical harvesting of all crops there is some waste which, while seriously objectionable, is accepted. A mechanical cotton harvester that drops even a relatively small percentage of cotton on the ground, gives a false impression that such loss is much greater than it really is, for even a trivial amount of white cotton scattered on the ground glaringly exaggerates the amount.

Like practically all farm crops, cotton cannot be successfully harvested when too green or wet, and it is just as impossible to do a satisfactory job of harvesting wet, green cotton as it is to harvest immature or wet grain successfully with a combine.

Cotton is grown in great variety and under widely variable conditions, plants varying from 6 to 8 in to 5 or 6 ft in height; the length of staple from $\frac{5}{8}$ to $1\frac{1}{4}$ in; the yield from less than one-fourth bale to as high as two or more bales per acre. Under certain conditions the foliage on the plants is extremely heavy. Under other conditions the leaves are destroyed by worms leaving only the skeletons. Cotton is damaged by the boll weevil, boll worm, and other insects, and the cotton rows are infested with weeds, vines, and grass.

In the development of spindles alone, hundreds of experiments have been tried. Spindles of almost every conceivable type, shape, and size have been tested. Particular care has had to be exercised in selecting suitable materials for spindles to make them durable and non-rusting.

In spindle design we have found that those which are less aggressive gather less extraneous matter, and hence produce a better sample of cotton, but more of them are required. A large number of spindles, with the necessary mounting and drives, tends to extremely high cost and maintenance relative to the work accomplished; consequently we have deemed it necessary to develop spindles sufficiently aggressive to pick a high percentage of cotton and to limit their number to the minimum to keep the complication, cost, and maintenance within commercial limitations.

The development of a satisfactory spindle has been but one of the many difficulties. The problem of removing the cotton from the spindles has involved the design and trial of many varieties of doffers and doffing arrangements.

As a result of all these trials and experiments, our spindle type of picker has been developed to a point where it will do a commercially satisfactory job under normal

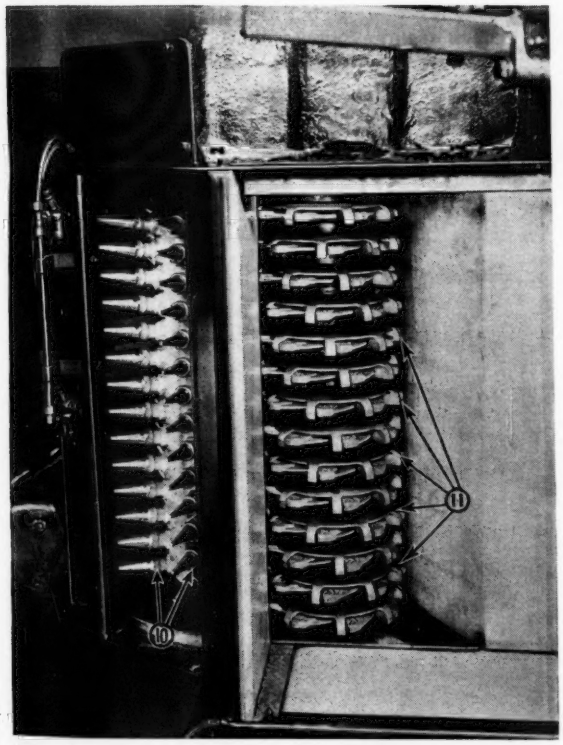
field conditions. A spindle has been developed which is sufficiently aggressive to remove practically all the cotton from the stalks, can be kept clean, does not seriously damage the cotton plants or immature bolls, and from which the cotton can easily be doffed.

Our successful development of an all-purpose tractor some years back gave us a new angle from which to tackle the difficult problem of designing a practical cotton harvester.

Some of our earlier cotton harvesters were of the self-propelled type, and others were of the pull type that were drawn behind a tractor and operated by means of a rear power take-off. But because of the excessive weight and cost of the self-propelled machine relative to its capacity, this type of machine was abandoned, and because of difficulties in following the rows and turning at the ends of the rows, and because so much cotton was knocked off by such a machine in passing over the plants, the pull-type machine was abandoned.

Since the advent of the Farmall tractor, our later harvesters have been designed as an attachment for these all-purpose tractors and the regular power take-off shaft drives the harvester mechanism. This affords a simple hookup, and since the whole picker attachment may be readily and quickly removed, the tractor is thus available for other farm operations.

The latest International Harvester cotton harvester of the single-row type is provided with two vertical and parallel revolving cylinders between which the cotton plants pass as the machine moves forward along the rows. From each cylinder protrude 154 spindles, or 308 of them in all, for the single-row machine. Each of these spindles has numerous tiny needles or barbs which catch the lint. The rotative speed of the picker drums is synchronized with the traveling speed of the tractor so that the projecting rotating picker spindles enter and withdraw from the plants without any raking action. As the rotating spindles penetrate the plants and contact the lint of the open bolls, the barbs catch the cotton and extract it, and as the drums carry these cotton-laden spindles around, the cotton is removed by doffers which rotate in close proximity to the spindles at a higher rotary peripheral speed than the spindles, and thus remove the cotton. The cotton then falls on a conveyor belt which carries it to a suitable receptacle.



IN THIS CLOSE-UP VIEW OF THE COTTON-PICKING MECHANISM, PANELS HAVE BEEN REMOVED TO SHOW TWO ROWS OF THE PICKER SPINDLES (10) AND ONE OF THE DOFFER UNIT ASSEMBLIES (11). THE TURNING SPINDLE DRUM BRINGS THE SPINDLES BEARING THE PICKED COTTON IN BETWEEN THE ROTATING DOFFERS WHICH REMOVE THE COTTON FROM THE SPINDLES. THE COTTON FALLS ON THE ELEVATING CONVEYOR BELT SHOWN AT BOTTOM TO BE CARRIED TO THE CLEANER

Our single-row mechanical harvester traveling at 2½ miles per hour will cover ½ to ¾ acre per hour, and the amount of cotton harvested depends largely upon the yield. Assuming the yield as one bale per acre, the machine under fair conditions will harvest 1500 lb of seed cotton in approximately 1 hr and 20 min. This 1500 lb of seed cotton, when ginned, makes a standard bale of 500 lb.

While some exceptional hand pickers can pick several hundred pounds of cotton in a day, the average is approximately 150 lb; so at this rate our single-row harvester would do the work of 75 hand pickers.

The cost of harvesting cotton by hand is extremely high, relative to the cost of harvesting other farm crops, and this cost is growing higher each year. In fact, during the past season the cost of hand picking in the Mississippi Delta was equal to half the market value of the cotton, and even under these conditions it was impossible to obtain enough hand pickers to harvest the crop, notwithstanding the great number of transients imported from Texas and other localities.

To depend upon transient labor for harvesting the cotton crop after all of the cost of producing has been incurred, is too hazardous to be contemplated. The mechanical cotton harvester is just one element to be considered in connection with the entire economic situation surrounding the cotton industry. So long as a large part of the cotton was grown by the share cropper and adequate labor could be obtained to pick cotton at 25 to 40 cents per hundred pounds, the problem of harvesting was not a serious one, but with the changed situation the rate has been increased to as high as $1 to $1.50 per hundred pounds for hand picking. This cost is prohibitive and the substitution of a practical mechanical harvester at reasonable cost becomes more necessary.

While the mechanical cotton harvester will no doubt be improved from time to time, nevertheless there are many other factors involved which must be given attention before they will come into general use.

All the varieties of cotton now being grown have been developed for high yield, length of staple, and hand picking, but results obtained by the experiment stations at Stoneville, Miss., Lubbock, Texas, and College Station, Texas, indicate that it is possible to develop hybrid varieties of cotton which will greatly facilitate machine harvesting. The problem is to breed a variety of cotton plant that is not so rank in growth, but which will be satisfactory in its yield and quality of staple. The phenomenal achievements of the late Luther Burbank in the genetics of other plants and fruits indicate what might be expected when such efforts are made with cotton plants.

In some cotton-growing areas, especially in wet seasons, the plants now grow to a size resembling small trees, while it is probable that good yields *(Continued on page 388)*

The Relation of Mechanical Harvesting to the Production of High-Grade Cotton

By Charles A. Bennett

THE DEVELOPMENT of mechanical cotton pickers has not yet reached the stage where it is easy to remove the trash of conjecture and wishful thinking from the lint of fact. At the U. S. Department of Agriculture cotton-ginning laboratories at Stoneville, Miss., we have been giving some attention to these new machines, and I am going to say a few things about what we have observed and what we have learned from others in the Department. I wish especially to acknowledge the help of F. L. Gerdes, A. J. Johnson, W. J. Martin, and Hughes Butterworth of the Bureau of Agricultural Economics and W. R. Humphries of the Bureau of Agricultural Engineering.

Our agricultural-engineering contacts with mechanical cotton harvesters, in projects of machinery for processing farm products, began in 1927 during the development of processes and equipment for drying seed cotton, and we have since continued to be in rather close touch with tests and demonstrations of these machines.

From these somewhat intimate observations, we are forced to the conclusion that while appreciable progress has been made, the problems of mechanical harvesting have not yet been worked out to the stage where we may expect to obtain high-grade cottons by existing mechanical means of harvesting and ginning.

Various objectives of mechanical harvesting have become clear, but thus far they appear to be to pick cotton "almost as good as" instead of "better than" by hand picking which is our criterion today. Objectives include the following:

1 To entirely replace manual harvesting by mechanical methods; or

2 To supplement manual labor continuously during the cotton gathering season; or

3 To clean up all late-season portions of open cottons remaining after defoliation of the cotton plants.

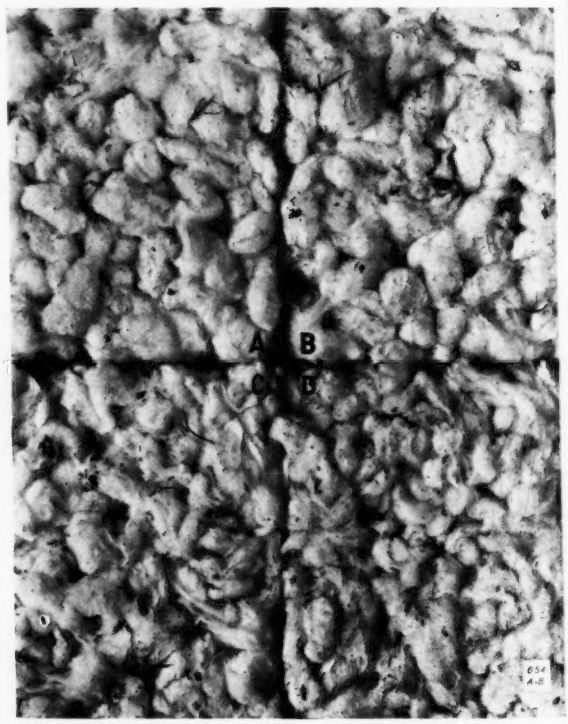
High-grade cottons can only be obtained from freshly opened portions of the crop, and these must have those characteristics of moisture and foreign matter contents which will permit ginning machinery to preserve the inherent good qualities of the cotton. The universal grade standards of classification for white cotton run from high to low grades as follows: (1) Middling fair (descriptive), (2) strict good middling, (3) good middling, (4) strict middling, (5) middling, (6) strict low middling, (7) low middling, (8) strict good ordinary, (9) good ordinary.

The processes of ginning are the bottleneck through which all raw cottons must pass in preparation for use in spun goods, yarns, and thread. Unfortunately thousands of ginning tests at the U. S. Cotton Ginning Laboratories have proved that existing conditioning, extracting, cleaning, and ginning machinery cannot fully restore to originally high-grade cottons those qualities that have been impaired by rough harvesting or improper handling.

Under such conditions it appears that the mechanical harvesting objectives must therefore be modified for an indefinite time so as to focus upon the quantity production of medium to low grades of cotton rather than upon those higher grades above middling which often are difficult to obtain even with manual labor unless the cotton is hand picked carefully, cleanly, and promptly after opening.

Within the confines of this paper it is possible only to touch briefly upon the principal kinds of mechanical harvesters that have been or are now in use. Sleds having comb-like bottoms, used occasionally in the past with large crops but obsolete now, were the crudest form of harvesters; strippers, with or without attachments, mark an improvement over sleds; and mechanical pickers, which are the oldest inventions of the group, with or without attachments, harvest cotton in better condition than do strippers.

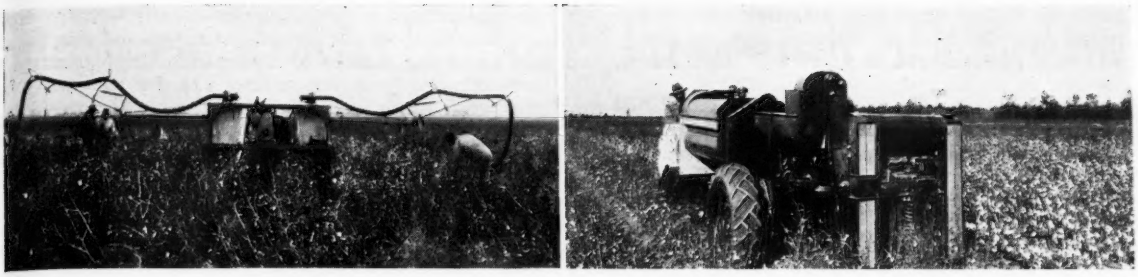
Strippers equipped with extracting and cleaning attachments have, in many instances, given good results, so far as capacity is concerned, but the cottons have never ginned out as high quality. Strippers thus fulfill in part objectives 1 and 3. In tests at the U. S. Cotton Ginning Laboratory



SEED COTTON HARVESTED BY HAND AND BY SPINDLE PICKER. A, EARLY-SEASON FIRST HAND PICKING; B, LATE-SEASON SECOND HAND PICKINGS; 3, EARLY SEASON MACHINE PICKING FIRST TIME OVER; D, LATE-SEASON MACHINE PICKING SECOND TIME OVER

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Pacific Grove, Calif., June 29, 1938.

Author: Senior mechanical engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mem. A.S.A.E.)



(LEFT) A SUCTION-TYPE COTTON PICKER WITH MANUALLY OPERATED PICKER HEADS. (RIGHT) A REAR VIEW OF THE COTTON HARVESTER DEVELOPED BY THE INTERNATIONAL HARVESTER COMPANY

on Texas stripped cottons, the highest grade we have been able to obtain has been low middling, or No. 7 from the top in the official standards of grade. Spindle-type mechanical pickers have, in very few instances, produced pickings that ginned out samples of strict low middling grade.

Regional conditions affect variously many elements in both harvesting and ginning. The arid regions of western Oklahoma and Texas have very short cottons and a scarcity of labor. Furthermore, the plant growth is usually small and uniform; the bolls mature and open within a comparatively short period; and the plants become defoliated relatively early and completely. Ginning establishments, representing investments of $40,000 or more per gin battery of five stands, can handle such cottons from strippers with fairly good results because the cottons are not high quality to begin with. But in such regions the lower capacity spindle-type machine pickers can hardly compete with strippers because of the relatively low yields.

In the south central areas of the United States where long-staple, high-quality cottons are grown, the strippers are not applicable, and the harvesting difficulties are much greater. Cotton plant growth is more profuse, larger, leafier, and more moist. Likewise the ginning problems of producing high-grade cottons are actually more complex, in addition to machinery set-ups being less complicated than in the southwestern regions. From these aspects one may glimpse the task that lies before spindle machine pickers in endeavoring to obtain high-grade cotton.

The Bureaus of Agricultural Economics and Agricultural Engineering in a mimeographed preliminary report[1] now in the process of publication state that "both types (stripper and spindle picker machines) gather an abundance of plant foliage along with the seed cotton. The bulk of the foreign matter in cotton harvested by the strippers is burs and stems, while in cotton harvested by the mechanical picker there is a preponderance of leaf trash, especially when the plant foliage is green and intact. In designing presentday cleaning equipment, manufacturers have directed efforts more toward the removal of burs and fine leaf trash, such as that present in snapped cotton, than toward the removal of large particles of green leaf that contaminate the quality of cotton harvested by the spindle or finger type of mechanical picker."

In an effort to speed up cotton harvesting, mechanical methods have been sought for and many different kinds developed. The main types of mechanical harvesters tested in recent years are of the stripper and the picker types. The stripper device is designed in such a way that the burs and much foliage are incidentally removed along with the cotton by stripping the plants between stationary slots or revolving rolls. The picker-type machine is designed to pick the open cotton from the bolls by means of spindles or fingers. These harvesters often leave an appreciable amount of cotton on the ground, and some cotton on the stalks.

Machine pickers may have their suction picking heads operated manually, or they may be strictly mechanical in all respects. They have been tried out (last year) on both early and late season cottons of high potential values and have gathered from 4.7 to 7.1 lb of foreign matter per 100 lb of seed cotton as compared with 1.8 and 6.6 lb by hand picking for the corresponding cottons.

Mechanical harvesters such as strippers and spindle pickers have thus far produced seed cottons in which leaf and other particles of foreign matter have become entangled in such a manner as to be difficult of removal by cleaning equipment in the gins. The large leaf particles are too large to be screened out, and excessive handling through cleaning and drying equipment may shatter them with attendant lowering of grade.

There is a striking difference in appearance between early cottons picked by spindle pickers and those which have been carefully hand picked. The machine pickings have a more matted, entangled, and wadded appearance, mottled with quantities of green leaf throughout the locks. Here and there are green juicy stains upon the fiber and some portions of bark, stems, and long grasses. On the other hand, the manual, early harvested clean cottons are outstanding for the natural color characteristics of the fiber, for individuality of locks, and for other general aspects of good quality.

At the gins during 1937 it was possible to remove only an average of 53 per cent of a total of 5.9 per cent of foreign matter (mostly leaf trash) from the mechanically picked as compared with 66 per cent from a total of 4.2 per cent of foreign matter (mostly burs) in the hand-picked cottons.

Percentages of cotton picked by spindle-type mechanical pickers have approached 90 per cent of the available open cotton, while the amount knocked on the ground has not been excessive, ranging from 3 to 8 per cent as the season advanced. When this seed cotton reaches the ginning processes, the moisture and foreign matter contents present many problems.

The results of our ginning experiences with these cottons have not been encouraging, except in isolated cases. On the average, the spindle pickers have produced lint from one to two or more grades lower than that from corresponding hand pickings. How near the more recent developments in mechanical pickers may approach the principal objectives is of course problematical.

It may be asked at this point what the spinning mills require, and how mechanically picked cotton can be eventually handled to turn out a good and usable product. As we have already pointed out, the present-day ginning pro-

[1]Cotton Harvesting and Handling, by F. L. Gerdes, W. J. Martin, and C. A. Bennett.

cesses are inadequate to cope profitably with mechanically picked long-staple cottons, although they are doing fairly well with the snapped and stripped short cottons and "bollies" of the Southwest.

The Bureau of Agricultural Economics reported[2] that spinning tests of cotton harvested with a new mechanical cotton picker which was extensively publicized last year have revealed that even with the use of full batteries of gin cleaners and extractors the machine-picked cotton was of appreciably lower grade and yielded much more manufacturing waste than hand-picked cotton from the same field and similarly treated. Cotton harvested early in the season by machine was more wasty, because of the green leaf picked with it, than cotton gathered later when the leaves had dried.

It may therefore be said (1) that we have not yet reached the goal of producing mechanically harvested, high-grade cottons with our present- day pickers and gins, despite the increasing number of encouraging developments that have occurred from time to time, (2) that the ginning industry has yet to find a satisfactory means for overcoming the difficulties presented in the ginning of mechanically picked cottons of existing characteristics, and (3) that the cotton breeders must develop now strains of cotton varieties which by special characteristics will especially make for better "pickability" on the part of mechanical pickers. The problem is therefore threefold and falls within the fields of activity of the cotton breeder, the manufacturer of the harvesting machinery, and the cotton ginner.

Be that as it may, so much has already been accomplished by the developers of mechanical cotton harvesters, by the manufacturers of ginning machinery, and by the cotton plant breeders that we look to their continued and combined efforts for additional improvements.

[2]Report of the Chief of the Bureau of Agricultural Economics, 1937, p. 13.

The Evolution of the Mechanical Cotton Harvester

(Continued from page 385)

of good quality can be grown on smaller plants better adapted for machine picking.

So far there has been no reason or incentive to develop special cotton gin equipment for handling machine-harvested cotton, but with the introduction of the cotton harvester it is reasonable to assume that cleaning and other gin equipment will be developed for handling machine-harvested cotton.

It also seems reasonable that the present code of grading cotton may be modified, so that it will be based more largely on the staple and quality of the lint rather than on a small amount of extraneous matter which it may contain, and which does not reduce the value of the cotton for commercial purposes. All cotton mills are equipped with machinery for removing such extraneous matter, and improvements in ginning equipment will no doubt result in the more efficient cleaning of their output.

I simply point out these possibilities as indications of what may happen, when and if mechanical cotton harvesters are marketed.

Although our later harvesters are showing fairly satisfactory performance under reasonably good conditions, we are still intensively engaged in developing necessary refinements. It would be contrary to the policy of our company to market these machines in quantity before they are fully developed, and following our usual procedure, we will probably continue to place a few machines with certain responsible and mechanical-minded growers who will be interested in giving them a fair and thorough trial on their own plantations.

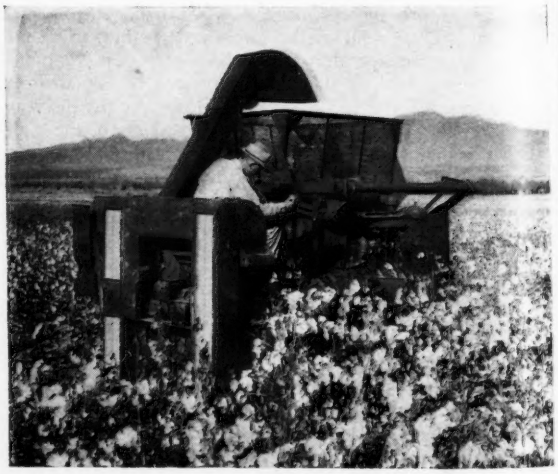
It is reasonable to assume that, under the most favorable circumstances, many years will be required for the general introduction of the mechanical cotton harvester, and therefore the probability of the social upheaval, of which we have heard so much, is very remote indeed.

The price of cotton fiber normally would be based largely upon the yield, as compared with consumption, which in turn is controlled to a great extent by the price of competitive fibers. This obviously means that we must find a way to produce cotton at a cost sufficiently below market price to give the cotton grower a reasonable profit in order to perpetuate this important industry, and it is probable that the successful mechanical harvester will become of greatest importance in this connection.

With a production in the United States last season of 18,740,000 bales (the largest on record), the carry-over on next August 1 expected to be the second largest on record, and an annual world consumption of American cotton of approximately 13,000,000 bales, it is not difficult to realize the necessity for increasing the consumption of cotton, reducing the cost of production, and controlling the amount produced.

To sum up, we know we are now on the right track at last, but we also feel that there is absolutely no likelihood of mechanical cotton harvesters being produced and sold in quantities sufficient to revolutionize agriculture in the cotton-growing areas in the near future.

While it is reasonable to assume that the demand for mechanical cotton harvesters will be stimulated by the increasing scarcity of hand pickers, the high and increasing cost of hand picking, and the necessity of reducing the cost of production, I cannot emphasize too strongly my belief that this demand will continue a long time before mechanical harvesters are used in sufficient numbers to affect seriously the labor situation in cotton-growing areas.



A COTTON HARVESTER IS SHOWN HERE WITH OVERHEAD HOPPER INTO WHICH THE PICKED COTTON IS ELEVATED. WITH THE OVERHEAD HOPPER THE NEED OF CONTINUALLY PACKING DOWN THE COTTON, AS IS THE CASE WITH THE BAGS, IS OBVIATED

Progress in Mechanical Harvesting of Cotton

By H. P. Smith

CONSIDERABLE progress has been made in the development of mechanical cotton harvesting equipment since I presented a paper to this group in December 1930. At that time the Meyercord cotton picker was at the height of its development, the Rust Brothers were testing their first model, and the engineers of the International Harvester Company were industriously and silently making progress on the development of their machine. During this interval of eight years we have lost sight of the Haring, the American, the Smith-Conrad, the Simplex, and a number of other cotton-harvesting machines that were being presented to the public. The field of promising cotton harvesting machines is now confined mostly to the following: The International Harvester Company, the Rust Brothers, Wind-Roll Cotton Picker Co., and the Texas Agricultural Experiment Station.

First, let us review briefly the trend of patents that have been granted on cotton harvesting equipment. When S. S. Rembert and J. Prescott of Memphis, Tenn., obtained the first patent on a mechanical cotton harvester in 1850, they had a clear vision regarding the future development of cotton culture in mind. They stated in their patent claims: "Our cotton picking machine may be multiple and extend to such a width as to embrace several rows of cotton plants at once." This was long before the era of the two-row, horse-drawn cotton planter and cultivator. Now we see thousands of two-row tractor outfits and many four-row tractor planters and cultivators weaving back and forth across the cotton fields in many parts of the cotton belt. One outstanding feature of the Rembert-Prescott cotton picker was that it was mounted on wheels and drawn by mules. This is rather significant, because most of the machines patented in the 1860s and 1870s were hand-operated machines and were, I am sure, more tiresome to operate than to pick cotton by hand.

From 1850 to 1880 only 35 patents were granted on cotton harvesters. Beginning with 1881 the number of patents granted annually rose until 17 were granted in both 1890 and 1891, after which there was a gradual decrease until none were granted in 1899. From 1904 until 1920 inventors of cotton harvesters were extremely busy, as they obtained over 300 patents during this period. The year 1922 marked another low period, and interest was at a low ebb until 1929, soon after the introduction of sledding in northwest Texas and western Oklahoma. From 1931 there was a gradual decrease until only four patents were obtained in 1936. Thus it appears to some extent that inventive efforts on cotton harvesters ebbs and flows with the periods of prosperity and depressions.

It will be of interest to note in which states men lived to whom patents were granted on cotton harvesting equipment. Illinois ranks first with 140, because of the location of the large implement factories. New York City, as a financial center, ranks high with 75. As a whole, more patents have been granted to men from the southern states than any other region. Of these, Texas ranks highest with approximately 120. Oklahoma ranks second with 44. The others range from 18 for Alabama to 36 for South Carolina.

As nearly as can be determined by information obtained from the U. S. Patent Office and a search through the Official Gazette, which lists all patents granted, it appears that approximately 850 patents have been granted on cotton harvesting devices. In numerous cases several patents have been granted on various features of the same machine. For example, the Rust Brothers, having one of the latest machines to attract attention, have obtained to date 10 patents. Other companies and individuals have obtained as high as 25 patents.

PUBLIC INTEREST IN INFORMATION ON COTTON HARVESTING

Some of the machines of the past have been well designed, but Nature, in creating the cotton plant and its characteristics and aided by the prejudice of mankind, prevented these machines from being a success. As the years have rolled along, men have learned more and more of the requirements of a successful cotton picker, and with the mechanization of many farming operations the large cotton grower is looking forward to the time when it will be possible for him to harvest his cotton crop with machines.

In the development of cotton harvesting machinery no doubt each inventor, in testing his machine, obtained much useful information which was carefully guarded and lost with his passing. Had all the information obtained by various men developing cotton harvesting equipment been made available to others working on the problem, I believe progress in developing mechanical harvesters would have been more rapid. Because such information was not made available, it has fallen to the lot of the federal and state research workers to go into the field to obtain data and make them available to anyone interested. Insofar as I can ascertain, the substation (No. 8) of the Texas Agricultural Experiment Station located at Lubbock, Texas, was the first of the experiment station staffs actually to collect data on the mechanical harvesting of cotton. The first active project on the study of the mechanical harvesting of cotton was approved March 6, 1929, by Director A. B. Conner of the Texas Agricultural Experiment Station. Since that date, active work on the problem has been in progress. As no scientific information on the problem was available, it took some time to get organized and set up a definite goal.

The early orientation of the experimental work on mechanical cotton harvesting was greatly aided by Mr. E. A. Johnston, whom we are honoring today with the McCormick medal for his outstanding work on mechanical cotton harvesting equipment. He, through his associate and coworker, B. R. Benjamin, gave me the unusual privilege of witnessing the testing of their 1930 experimental cotton pickers and cleaners. At that time Mr. Johnston was a veteran and I a mere cub in working on mechanical cotton harvesters.

It was the same year 1930 that George R. Meyercord's engineers brought the "Gyracotn" picker to the A. & M. College of Texas and made tests on several different varieties of cotton. They returned in 1931 for further tests.

Paper presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Pacific Grove, Calif., June 29, 1938.

Author: Chief, division of agricultural engineering, Texas Agricultural Experiment Station, A. and M. College of Texas. (Mem. A.S.A.E.)

During the same period the Rust Brothers were testing their picker on the John Gorham Farm near Waco, Texas. They came to College Station and invited us to see their machine work on October 27, 1931. It was in 1930 and 1931 that the Berry, the American, the Haring, and the Simplex cotton pickers, and the Smith-Conrad, the Boone, the Friend, and the John Deere cotton strippers were being demonstrated.

As far as I have been able to ascertain, Deere and Company has manufactured and sold to cotton farmers more cotton harvesting units than any other concern. Yet, strange as it may seem, few units of any kind have been sold during the past five years. The question naturally arises as to why this apparent lack of interest on the part of the cotton farmer. I would not say that he has lost interest, but the lack of sales can be largely attributed to economic and labor conditions. The price of cotton has been low, and labor has been abundant and cheap, except probably in a few sections where high yields were obtained.

The High Plains region of northwest Texas produced in 1937 approximately 1,000,000 bales of cotton, with three counties producing 425,000 bales. Labor was available to harvest the crop so rapidly that, although the gins operated on a 24-hr schedule, they were overrun with cotton. Farmers, until stopped by risk insurance inspectors, unloaded hundreds of bales on the gin yards. They then harvested and piled cotton in the fields to wait until the gins could handle it.

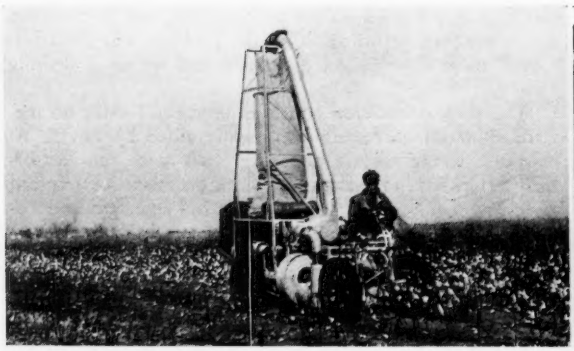
It is estimated that in 1937 at least 1½ million bales of cotton in Texas alone were harvested by the hand-snapping method, commonly called "pulling" by the farmers of the region. The practice of pulling is spreading over the state until gins within 100 miles of the gulf coast are installing equipment to handle pulled cotton. Pulling cotton in northwest Texas has been practiced for the past 15 or 20 years, and it was primarily for this reason that the Texas station has devoted its attention to the development of the stripper type of cotton harvester. The early work was done with homemade "sleds" or strippers. These, however, soon proved unsatisfactory because of their low efficiency and the large amount of dirt and leaf trash collected.

In 1930 a tractor-mounted stripper was developed and tested on several varieties of cotton. With this model 88.6 per cent of the cotton on the plant at harvest was harvested. This percentage was too low. To improve this machine studies were made to determine the effect of different sized stripping rolls, the angle of the rolls to the ground, the best material and type of surface for high efficiency, the rate of tractor travel, and the relation of peripheral travel of the rolls to tractor travel. By means of such studies we have perfected our cotton stripper so that in our 1937 tests we harvested an average of 97 per cent of the cotton on the plant from 7 varieties at College Station and an average of 98.8 per cent from 13 varieties at Lubbock. The burs were extracted and the green bolls thrown out with the burs, and a high percentage of the green leaves and other trash was removed by the Station extractor, which was also mounted on the tractor. Just enough greenleaf material was left in the seed cotton to make it necessary to sun-dry the cotton for a few hours. Our goal is to harvest and clean the cotton in the field so that it will be comparable with hand-picked cotton and can be carried directly to the gin without sun-drying. After the samples were cleaned on our vertical cleaner, the cotton was ginned and the lint classed by an official and licensed cotton classer. The machine-stripped cotton at College Station averaged strict low middling plus and the hand-picked cotton middling plus, a difference of one grade. The machine-stripped cotton from the 13 varieties harvested at Lubbock averaged middling, the hand-snapped or pulled cotton averaged strict middling, and the hand-picked cotton averaged good middling, a difference of one and one-half grades between hand-picked and machine-stripped cotton, and only three-fourths of a grade between hand-pulled and machine-stripped cotton.

ADAPTING THE COTTON PLANT TO MECHANICAL HARVESTING

From the very beginning of our work it was recognized that the efficiency of any mechanical harvesting device would be greatly influenced by plant characteristics. The first work consisted of studying the storm resistance, the length and number of fruiting and vegetative branches, size of leaves, weight of bolls, and height of plant on 12 varieties commonly grown. Of the original varieties selected, only one has been retained throughout the entire period. This variety has a large boll, good storm resistance, and a medium growth. In studying the reaction of these varieties to the homemade sled it was found that long branches and dense foliage were undesirable characteristics, and the commonly grown varieties were not suitable for mechanical harvesting.

We needed a new type of plant, one having storm resistance, good extracting qualities, short fruiting branches, a tenderable staple of 7/8 to 1 in in length, and a minimum amount of foliage. When the project was reorganized in 1930, therefore, we were fortunate in obtaining the co-



(LEFT) THE COTTON PICKER DEVELOPED BY A. R. NISBET. THE COTTON IS HELD AGAINST A REVOLVING CYLINDER OF EXPANDED METAL BY A BLAST OF AIR. AS THE CYLINDER REVOLVES, IT PULLS THE COTTON FROM THE BOLL. (RIGHT) THE STRIPPER TYPE COTTON HARVESTER DEVELOPED BY THE TEXAS AGRICULTURAL EXPERIMENT STATION. NOTE THE AMOUNT OF GREEN FOLIAGE ON THE PLANTS BEFORE AND AFTER HARVEST

operation of two cotton breeders, D. T. Killough at College Station and D. L. Jones at Lubbock, both on the Texas station staff. Their work consists chiefly of studies to determine the adaptability of varieties to mechanical harvesting and to develop a variety, or varieties, better adapted to mechanical harvesting than the commonly grown varieties. The first variety was developed by crossing two varieties, Durango and Wacona. The progeny was called Ducona. This new variety had short fruiting branches and the bolls borne in clusters, often with the bolls fused together. It had extra large leaves and a tendency for the top squares to abort. After testing with the machine it was found that the close clusters, very short fruiting branches, and large leaves were a disadvantage. The breeders had given us almost what we had asked for, but it did not react to machine harvesting as we had hoped. We wanted short branches, it is true, but not too short. We, therefore, modified our specifications and asked for a plant with restricted vegetative growth, a determinate fruiting habit, relatively large stormproof bolls borne in semi-clusters but singly on long thin peduncles, and a small leaf or a deep-lobed leaf commonly called cut-leaf. This type of plant is now being developed and, when obtained and fixed by backcrossing and hybridization, it should not only be adapted to the stripper type harvester but also to the mechanical picker and good for hand picking. Along with the development of a new variety having certain specific characteristics, we are testing other varieties and strains that look promising. For example, in 1937 we included in our harvesting tests 41 different varieties and strains at College Station and Lubbock.

ENGINEERS AND PLANT BREEDERS COOPERATING ON COTTON IMPROVEMENT FOR MACHINE PICKING

The general set-up is rather unique in that the engineer makes a machine and tells the plant breeder the characteristics he desires; then when the breeder produces a variety having most of the characteristics, the engineer tests it with his machine. While harvesting, the engineer must collect data on the yield and the harvesting, extracting, and cleaning qualities of the variety. He checks on the percentage of cotton harvested, the amount of leaf trash, the strength of the boll (whether or not it crushes badly), the ease with which the cotton is extracted from the burs, the amount of dirt and leaf trash removed, whether or not the cotton machines badly, and whether or not it has a tendency to twist and rope in the extracting and cleaning equipment. After this is done, he gins the cotton, getting the lint turn-out, and has a licensed cotton classer to class the lint for grade and staple. When all data have been tabulated, the engineer and the breeder study the various factors, picking out the good and bad points, and decide which characteristics need improvement and which should be eliminated.

Sometimes we need information that cannot be obtained from the harvesting tests and special data must be collected. During the past three years we have been studying the snapping qualities of cotton bolls, the length and size of the peduncle, and the degree of boll spread. This study has revealed that varietal characteristics and weather conditions are the important factors influencing the snapping qualities of cotton bolls. When a boll opens wide and the sections approach an angle of 180 deg, the storm resistance may be affected, but, on the other hand, a well-opened boll is essential for the mechanical picker. A test made with a cotton picker on two varieties, one having an average boll spread of approximately 90 deg and the other 130 deg, showed that the machine picked all the cotton from 17 per cent of the bolls on the former and 39 per cent from the latter. No cotton was picked from 14.5 per cent of the bolls where the spread averaged 90 deg and 8.9 per cent where the spread averaged 130 deg.

A study of such varietal characteristics will answer the question of why a machine will pick a higher percentage of the cotton in one field than another. It also lends a little light on why a cotton picker will do better work one year than another in harvesting the same variety. The degree the boll is open varies with the season. During a dry hot period it appears that the outer surface of a mature boll drys quickly, and this rapid shrinking of the plant cells pulls the sections of the boll open more than when they do not dry as rapidly. This action is also less as the season advances into cool nights and heavy dews.

FACTORS DELAYING DEVELOPMENT AND WIDESPREAD USE OF COTTON HARVESTERS

A knowledge of such various varietal characteristics and seasonal conditions reveals why there have been so many failures of mechanical cotton harvesters and also why the agricultural leaders and the cotton growers of the South are slow to accept the mechanical cotton harvester to harvest cotton from the commonly grown varieties. We cannot expect a cotton harvester to harvest equally high percentages of cotton from all varieties grown. Those varieties that the picker can harvest best may not give the highest yields. To introduce a successful mechanical cotton harvester, therefore, it is also necessary to select a variety well adapted for the purpose and to practice methods of culture that will aid the machine when it operates in the field. To accomplish all this will take time for the breeder to give us a suitable type of cotton, a great amount of persuasion to get the cotton farmer to change to the new variety, and many demonstrations to prove the efficiency of the machine.

Other factors that hinder the use of a mechanical cotton harvester are topography of the field, including percentage of slope, straightness of the rows, and the number of terraces; size of farm; acres of cotton grown; average yield; the price of cotton, and the availability of labor at harvest. Personally, I cannot visualize the mechanical cotton harvester taking the cotton belt by storm, because the 1935 census shows that for 12 of the cotton-producing states, 30 per cent of the farms range in size from 3 to 49 acres and 20 per cent are from 50 to 99 acres in size. All the land is not planted to cotton and considering that the average yield is about one-third bale to the acre, a man owning a farm of 100 acres or less could hardly afford to pay $1500 to $2000 for a mechanical cotton picker.

It appears that when some writers hear of how the mechanical cotton picker is being perfected, they immediately assume that the entire crop of 15 million or more bales will be harvested by machines. They also assume that enough machines can be manufactured in a year or two to supply all the farmers and that there could be a great upheaval in the social life of the South. Such predilections are probably made by men who do not now and have never lived on a cotton farm.

I do believe, however, that there will be small acreages here and there throughout the cotton belt where mechanical harvesters will be used in the near future. This will take place gradually and not be enough to cause any great change in the social life of the people.

Mechanical Cotton Harvesting Experience in California

By H. B. Walker

CALIFORNIA has had varying acreages of cotton ranging from 200,000 to approximately 600,000 acres. The maximum acreage was in 1937, but this has been reduced about forty per cent this year because of quota regulations. The principal cotton counties are Merced, Madera, Fresno, Tulare, Kings, and Kern Counties. A small amount is grown in the Imperial Valley region.

California grows a variety known as Acala, and this produces rather heavily under irrigation conditions. The average yields have been considerably in excess of a bale to the acre in recent years. The plants will vary in size from 12 to 72 in with the most normal size ranging from 27 to 48 in. Irrigated cotton normally has strong vegetative branches and it is not well suited to the stripping method of harvesting. It is for this reason that California growers are extremely interested in harvesters which can be used for harvesting when there are varying stages of maturity of the fruit.

Some time ago (1930) field tests were made with a finger type mechanical picker. This machine (the Gyracotn) may be equipped with either one or two pairs of vertical cylinders on which are mounted the picking fingers. Each cylinder has approximately 800 fingers and these may be either 2 or 3 point. The peripheral speed of the 14-in diameter by 29-in long cylinders is higher than the forward speed, and one cylinder is operated at higher speed than the other to give a slightly rolling motion to the plant as the rapidly rotating screw tip fingers pass through the stems and foliage. The peripheral speed of one drum is 136 per cent of the forward speed while the other is 127 per cent. These fingers rotate at high speed, something over 3,000 rpm and reverse in direction for cleaning and to deliver the seed cotton to the air lines which suck up and deliver the harvested cotton to the bins. This machine has narrow tread (about 36 in), is mounted on rubber-tired wheels, and is self-propelled by an internal-combustion motor mounted at the rear.

The first field test was made in the Kern Lake district of Kern County in Acala cotton averaging about 34 in high and yielding about 420 lb of lint cotton per acre. During this test the machine was equipped with one pair of cylinders studded with two-point fingers. The forward speed was 3.5 mph. The first time over it picked 59.4 per cent of the open cotton, and this contained only 2½ per cent of burs and trash. The second trip secured 15 per cent more cotton, of which 7.3 per cent was burs and trash; 17.3 per cent was knocked from the plant as shatter cotton, and 8.3 per cent was left on the plant unpicked.

Following this test the machine was equipped with two pairs of cylinders, or a total of four cylinders, the forward ones operating the same as in the first test and the rear ones operating in a similar way, except that these were equipped with three-point fingers. The forward travel speed was 3 mph. In this test, once over removed 83 per cent of the ripe cotton; 8¾ per cent was knocked off as shatter, and 8¼ per cent was left on the plant. The machine-picked cotton was 9 per cent trash, of which 4 of the 9 per cent was dry burs and the remainder green leaves, dry leaves, and stems.

The cotton for this test (Acala) averaged 33 in high with 87 plants per 100 ft of row. Each plant averaged 12 open bolls, 33 per cent of which were 9 in from ground; 45 per cent 9 to 18 in above ground; 17 per cent 18 to 27 in above ground, and 5 per cent above 27 in. The cotton yielded 435 lb of lint cotton or 1150 lb of seed cotton per acre. In this test 1270 lb of seed cotton were picked at the rate of 22 lb per minute, or approximately one bale of 500 lb of lint cotton per hour.

The cotton picked in this test was taken to the gin and ginned 37.8 per cent, producing a 480-lb bale of lint cotton. Samples were cut from both sides of the bale and sent to the cotton association at Bakersfield for grading. It was graded as strict middling, which was equivalent in grade to hand-picked cotton from the same field.

So far as I know, this was the most successful field test ever conducted for any type of picker in California. At that it had certain shortcomings which probably can only be partially corrected. The most serious drawback is the ground shatter. In the first test this was 17.3 per cent. Changes in the machine reduced this to 8¾ per cent. If this can be reduced to 5 per cent or less, the performance would be most encouraging. This machine does not seriously injure the green plants, although approximately 16 per cent of the green bolls were knocked from the plants.

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Pacific Grove, Calif., June 29, 1938.

Author: Professor of agricultural engineering (head of division), University of California. (Fellow A.S.A.E.)

Publicity for Engineering

WHEN it comes to publicity for industry and engineering, some delicate questions are involved. It cannot be assumed, as the politician is said to assume, that bad publicity is better than none at all. Politicians are individuals and their days are few. Industry and engineering are important factors in the social structure. Good publicity can aid them and the public they serve. Bad publicity, popularly known as "propaganda," can only aid by uncovering their weaknesses.

Because truth usually prevails eventually, those who are responsible for publicity on matters relating to industry and engineering should adopt an objective and realistic approach to their work. It is possible, as Robert Potter, of Science Service, pointed out at the Philadelphia forum of the American Engineering Council, to lead the public to expect the impossible, or the improbable. Pulling rabbits out of hats should be left for magicians. On the other hand, the glib traducers of engineering and industry should be exposed. Although time will deal with them, man's days are few, and hostility to technology, a vital motivating force in modern society, may retard development and result in unnecessary hardship to many persons.

From an editorial by the same title in "Mechanical Engineering" for August 1938.

Some Needs in Cotton Harvesting Development

By W. Waterman

FOR MORE than eighty years the tremendous amount of hand labor required for the production of cotton has served as an incentive to develop means of harvesting cotton mechanically. Originally all efforts were limited to that of reducing the labor in harvesting. However, since the advent of the tractor and of modern cultivating machinery, it has been repeatedly demonstrated that savings can be made in most of the other necessary operations such as preparation of the land, planting, and cultivating. But extensive use of the tractor by the cotton producer has been relatively impractical due to the fact that he still must assure himself of a sufficient supply of labor for harvesting his cotton. However, the supply of labor is not always equal to the demand, with the result that cotton stays in the field much too long, suffering a serious loss in grade. Therefore, a mechanical cotton picker is needed to reduce the hand labor involved in harvesting.

This need has resulted in thousands of patents, the expenditure of millions of dollars, and the construction of scores of mechanical cotton pickers. One of these is the Gyracotn harvester, the construction of which resembles that of a light tractor, and which is provided with a gasoline engine to drive it through the fields and to operate its various parts. It is equipped with two barrel-shaped drums, each of which is studded with approximately 800 picker fingers projecting only a fraction of an inch from the face of the barrel. The machine is driven through the fields straddling each row, the plant passing between the two barrels which are rotating with a peripheral speed slightly higher than the forward speed of the machine. The process is very similar to one seen in a domestic laundry where clothes are passed through a wringer. Of course, the clothes move through the wringer, which stands still, whereas the cotton plants stand still while the drums pass along each side. While rolling between the two drums, the cotton plant is concentrated into a space about two inches wide. The small picker points project into this two-inch space, and inasmuch as they are placed very close together it is impossible for an open cotton boll to pass through the machine without being touched. At the same time, sufficient space is allowed so that green bolls, leaves, and blossoms pass through unharmed.

PICKING ACTION OF THE GYRACOTN HARVESTER

The picker points referred to are small rugged hooks rapidly rotating as they come in contact with the cotton. The ripe boll freely exposes a small bunch of cotton weighing about one-quarter of an ounce. The nature of the cotton itself is so different from other parts of the plant that the blunt hooks engage it with great ease but take up nothing else. They engage the cotton by a twisting action; they separate it from the plant by twisting and pulling; they carry it into the machine, and then throw it off by a reversal of the twisting action. The hooks are then treated by a polishing brush and go out to repeat the process. Meanwhile, the cotton that has been thrown off by the hooks is delivered to a large collection box by the air conveyor, which after picking it up blows it against a grill deflecting the loose cotton downward into the collection box and allowing dirt and other foreign particles to escape into the air.

The picking hooks are driven entirely by friction; and the friction drive parts are sturdily built and are so constructed that they automatically compensate for wear, keeping a uniform picking torque at all times. The machine is streamlined in those places where it comes in contact with the cotton plant so as to gently deflect the projecting branches without harming them. Where necessary, front guides are provided to lift low hanging limbs up off the ground and guide them between the picking drums.

FACTORS APART FROM THE HARVESTER WHICH INFLUENCE SUCCESS OF ITS USE

It is believed that the essential details of this machine have been brought to such a stage that complete machines can be produced which will be commercially practical, but before it can be used universally, however, further development and educational work must be done. To date almost all of the work has consisted in producing a machine to fit the cotton; future work must include that of producing cotton and cotton fields to fit the machine. This work must necessarily be considered as the responsibility of such organizations as the American Society of Agricultural Engineers, the state universities, and the U. S. Department of Agriculture.

The problem may be compared to that of the automobile. In 1910 almost everyone conceded the mechanical success of the automobile, but very few people could use them. It was necessary for the federal, state, and local governments to construct roads and to provide other facilities before the public could really get the full benefits of the automobile. Likewise the American cotton producer must be helped; he must be shown the best methods for planting and cultivating to accommodate tractors and mechanical pickers; he must eliminate stumps and deep ditches; he must have available knowledge of what types of cotton are best adapted to mechanical picking and what methods of cultivation will best enable him to keep his fields clean of vines and other foreign growths. He should have data showing him what per cent of his cotton crop he can afford to lose in harvesting and still profit from mechanical farming.

A great deal has already been accomplished by such men as H. B. Walker of the University of California, by D. Scoates and H. P. Smith of the A. & M. College of Texas, by Director Ayres of Mississippi, and also by the Department of Agriculture. A continuation of the excellent work started by these men will hasten the advent of mechanical cotton farming.

Paper presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Pacific Grove, Calif., June 29, 1938.

Author: For several years engineer for George R. Meyercord and Associates, who developed the Gyracotn harvester.

Following are enumerated a few of the points meriting attention:

Type of Cotton. Most types of cotton have a growth on the under side of the leaves similar to small hooks, which make them cling tenaciously to lint cotton with which they come in contact. Other types found in California and Texas do not have this growth, and because of this characteristic are much better adapted to mechanical picking, as the leaves do not tend to follow the cotton into the machine. Furthermore, separation of leaves in ginning is much less difficult. The extent of this growth seems to vary considerably, but it is altogether possible that a happy medium can be arrived at for most cotton and the problem eliminated altogether.

Fluffiness of the Cotton Boll. Certain types of cotton are pulled from the bolls very easily, whereas other types cling tightly. Often the cotton that is loose in the boll is in the form of a very compact lock and does not fluff out well. It naturally is more difficult for the small picker to get hold of such locks, while at the same time a slight shaking of the plant very often causes the locks to fall to the ground. This characteristic was found to be most prevalent in California. Whereas in all other types of cotton the machine rarely dropped more than 2 per cent of the cotton, as high as 8 and 9 per cent of the California cotton fell to the ground.

Amount of Foliage on the Plants. A considerable amount of work has already been done to produce a cotton plant having only a single stalk with few branches and leaves. A mechanical picker would be at a decided advantage with cotton of this type.

Brittleness of the Plant Stems. Whereas in certain types of cotton the plant is extremely tough, in others, even when the plant is quite young and green, the leaves and branches have a tendency towards brittleness which allows branches to be broken and leaves to fall off very easily.

Height of Plant. Obviously a mechanical picker cannot be expected to harvest cotton 5 or 6 ft high. A height of 48 in should be considered the maximum.

Ginning and Cleaning Process. Cotton picked in dry climates very seldom presents any serious problem in eliminating leaves or other foreign particles, whereas cotton picked in localities with high humidity, such as the Mississippi Delta, requires special treatment in driers in order to get the best results. Furthermore, where mechanically picked cotton contains any appreciable amount of green leaves, certain types of cleaners are much more effective than others, in that some types, having been built for the separation of small dry particles, have a tendency to chop up the green leaves making them almost impossible to remove, whereas others working on different principles cause no difficulty whatsoever.

Condition of Fields. Naturally a mechanical picker cannot be expected to operate in a field littered with boulders or having hidden stumps. Deep ditches must be avoided except where they are at the end of fields or where they are running parallel with the roads. Low spots in the fields should be kept drained as well as possible. Most of these are requirements not only for a mechanical cotton picker but also for a tractor.

Trustworthy Data on Losses. Reliable information from impartial sources is needed to show the cotton producer (1) what losses he may expect to have in the mechanical harvesting of his cotton, (2) what his losses are in hand picking, and (3) what losses are common in harvesting other crops by machine and by hand. This third point is an extremely important one, and one which must necessarily be presented to the prospective user of mechanical picking equipment by unbiased organizations, rather than by the manufacturer.

VISIBLE AND INVISIBLE LOSSES COMPARED

A mechanical picker cannot be made which will pick 100 per cent of the open cotton without also taking a large amount of green leaves and bolls and branches, creating a considerable loss in the value of the cotton. Any amount left on the plant is considered by the farmer an absolute loss. However, this is not entirely true. As an illustration, assume that the field produces 1000 lb ready for picking on September 15, and another 1000 lb ripens later in the season. If the machine picks 85 per cent, or 850 lb, this leaves 150 lb on the plants. Before the next picking, a certain amount of this will fall to the ground, but it is reasonable to assume that at least two-thirds will be on the plant at the second picking, the total then available being 1100 lb, of which the machine will again pick 85 per cent, or 935 lb. The total amount picked is then 1785 lb, or more than 89 per cent of the crop. A certain amount of the balance will be knocked from the plant by either the machine, wind, or rain, but the majority of it can be gleaned at very low cost. In any event, the total loss should not exceed more than 6 or 8 per cent. The average person, however, does not like to accept any loss, even though it is this small. This 6 or 8 per cent of lost cotton has cost as much per pound as did the harvested product, and, besides, this lost product remains for a long time prominently seen in the field; it is not a concealed loss such as constitutes the principal loss in hand picking. The best available data indicate that losses considerably larger are usual with hand picking but are not noticed. They are caused in part by carelessness of the pickers, but principally by wind and rain, because of the fact that the cotton stays in the field for months, sufficient labor for picking at the proper time not being available. Furthermore, a terrific loss is taken in grade when the cotton stays in the field too long. A few windy days with dirt and sand blowing into the cotton, followed by a rain, can easily reduce cotton one grade, with a loss of perhaps $2.00 or $3.00 per bale. If cotton can be picked at proper times, such grades as ordinary, good ordinary, strict good ordinary will probably disappear almost entirely from our markets.

HARVESTING LOSSES COMMON TO OTHER CROPS

Furthermore, losses of even greater amounts may be the usual thing in the harvesting of practically all other products. Trustworthy data on losses commonly found in harvesting such crops as corn, potatoes, wheat, oats, rye, alfalfa, etc., together with the reasons therefor, should be appreciated by the cotton producer. The small loss of the nearly finished product in cotton harvesting is simply one of the many items that need to be considered in the two types of production—complete mechanical farming vs. mule farming and hand picking.

Such essential information as outlined above is not now readily available. It is important that such data be collected and presented clearly and repeatedly to the cotton producer. Mechanized cotton farming can be brought about only by an intensive educational and development program. Such activities will not only help the American cotton producer regain his losses in the world cotton market but will once more make cotton a profitable product.

Simplified Determination of the Safe Yield of a Groundwater Basin

By G. E. P. Smith and J. C. Hiller

HYDROLOGIC study of groundwater generally has been circumscribed within narrow limitations. Each basin presents a separate problem. Ofttimes the study has been limited to the geology of the basin and an account of the pumping development to date. In a few cases, such as that of the Owens Valley, the inflow and outflow factors have been evaluated reasonably well. But in general quantitative studies of groundwater supplies are costly and require many years of time.

This paper describes the measurement of the safe annual yield of a groundwater basin with a fair degree of accuracy, at low cost, in a period of two years. Several favorable circumstances contributed to its accomplishment.

The basin is an enlarged section of the Santa Cruz Valley between the Sasco hills and Casa Grande Mountain in Pinal County (Arizona). It includes the village of Eloy, the principal shipping point. The area is shown on the accompanying map.

The valley here is about 17 mi wide, with excellent soil over most of the area; the topography is smooth and the desert vegetation easily removed. The area would have been settled long ago were it not for the great depth to the water table, the high lift making necessary expensive pumps and pumping. In its virgin condition the depth to water varied from 130 ft at the south end of the area to 85 ft around Eloy. Beginning some ten years ago, a few wells were drilled and the water was used for high-priced crops, mostly lettuce and peas. The water table was lowered about 8 ft in 6 yr in one section of the pumped area.

Notable improvement in the design and the efficiency of deep-well turbine pumps, reduction in the electric power rates, and favorable prices received by farmers for cotton in 1935 and 1936 brought about a sudden expansion of agriculture in the Eloy district. About 4,000 acres of newly cleared land were planted in 1936 and 13,500 acres additional in 1937. Forty-four new wells were drilled, all of them of 20-in diameter and nearly all to depths of 500 ft or more, each well in most cases serving to water a half section of land.

With the overly rapid development of pumping, it became important to determine as soon as possible the extent and the permanence of the irrigation supply. At the same time, there was offered the opportunity to make general studies of a virgin underground storage reservoir, and of methods of investigating groundwaters.

The Santa Cruz River, emerging from the narrows between the Sasco hills and Picacho Peak, has built a great alluvial fan reaching to and beyond Eloy and merging into plains that extend to the Gila River. On normal and dry years, the stream flow is of little consequence. But on occasions of great floods the stream flow is bifurcated at the head of the fan. The right-hand branch is divided 4 miles south of Eloy into two branches, and each of them is split into fractions farther to the northwest. The left-hand main branch extends westerly to a playa called Green's Reservoir, and thence northwesterly toward Maricopa. At the head of the fan the main branches flow in channels, but farther on the various streams during flood flows are spread over wide draws of silt or clay. The flows are few and short-lived. Opportunities for deep percolation to the groundwater table are very limited.

The Eloy district is a partially closed basin. The main source of water supply is from the Santa Cruz River, with contributions from the surrounding low mountains and from three small tributary drainage basins. The outflow on the surface and underground is toward the north and northwest.

Well logs reveal alluvial silts and silty clays and occasional strata of sand and gravel to a depth of 500 or 600 ft. Below these deposits are older alluvial materials, mostly of fine texture, in which the water is confined under subartesian pressure. The greatest artesian pressure found was 58 ft, in a 930-ft well in the southeast corner of Section 25, T. 8 S., R. 7 E. However, in all such wells the pressures have been found to become exhausted during the pumping season.

Studies of the water table were made before and after each pumping season with some intermediate measurements when opportunity was offered by shutdowns. Depression cones were developed around all the irrigation wells, and where several wells were located in the same district the depressions were deepest, proving the mutual interference and the competition between the wells.

An automatic water-level recorder was maintained on an unused well in Section 24, T. 8 S., R. 7 E. The nearest pumped wells are 1.0 mi south, 1.0 mi east, and 0.7 mi northeast.

In the movement of underground water, time is an important factor, and therefore when measurements of water level in wells are made a few days or a few weeks after cessation of pumping, there is considerable doming of the water table between wells—that is, there are irregular water-table ridges between the cones of depression. So far as can be ascertained, these domes or ridges are quite thoroughly flattened during the winter and the water table in March appears to be one smoothed basin, except in the places where some winter crops are raised. The yearly computations should be based on the March-to-March year, but the fall records are helpful, and at least they indicate the amount of doming.

In the Eloy district, the pervious alluvium is deep and of great uninterrupted breadth. Consequently, the groundwater lateral circulation is unusually good, and the amount and the persistence of doming is moderate. The doming has been studied by observing the lag in the effect of pumping at irrigation wells on neighboring unused wells or on domestic wells from which the draft is trifling. A good set-up would be the case of an unused well between two pumped wells spaced about equally.

As an illustration, Fig. 1 is presented. The lower graph is the water level record taken by means of a Stevens Class A

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Authors: Respectively, head of the agricultural engineering department (Mem. A.S.A.E.) and assistant agricultural engineer, University of Arizona.

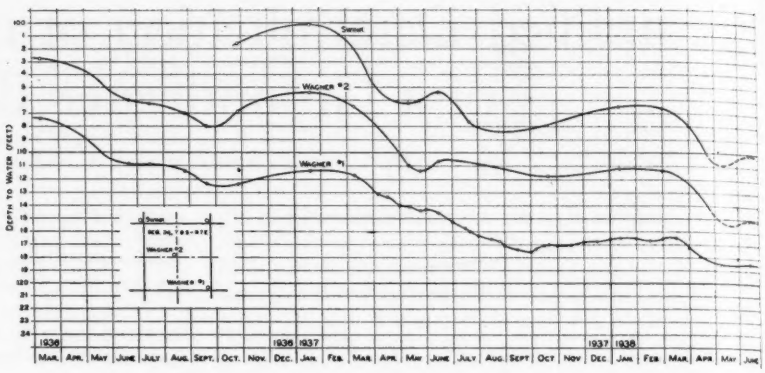
recorder. It shows for each of the two years a lowering of 5 to 6 ft due to pumping at distant wells and a recovery of one foot the following winter. The middle curve is for Wagner No. 2 well, 0.7 mi to the northwest. It was used in the fall of 1937. The upper curve is for one of the surrounding cordon of used wells. The unused wells are seen to be very responsive, and the two records differ but little. Always in March, however, the interval between them is 5 ft.

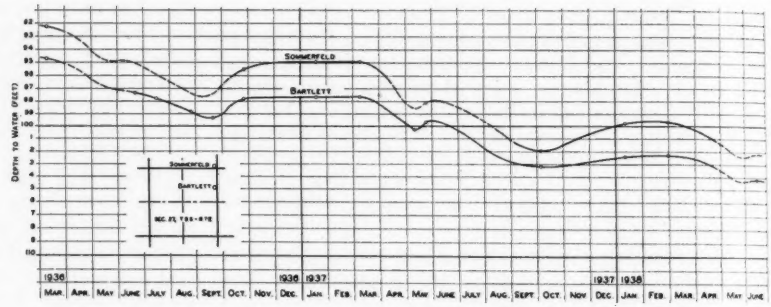
Fig. 2 similarly shows the effect of a pumped well on the Bartlett unused well, 0.25 mi distant. There is a little lag in the summer, but none in the winter. Fig. 3 shows the effect of the Frazier well on the Cantillo domestic well, with scarcely any lag.

These and similar records prove that the March records of water levels at the observed wells, which now number 120, can be accepted as defining the water table accurately, and thereby the volume of ground unwatered can be computed.

The quantity of water pumped is obtained by multiplying the acreage of each crop by the quantity used per acre. The latter was obtained for cotton, the principal crop, by obtaining the pump discharge, the power used per acre-foot, and the watt-hour record through the season for thirteen pumping plants. A crop survey was made twice each year.

For the 1936 irrigation season ending in March 1937, it was found that the pumping draft of 38,000 acre-feet of water resulted in the unwatering of 170,000 acre-feet of the pervious deposits constituting the valley fill. The residual lowering of the water table was from 6 ft in the center to 3 ft on the edge of the main pumping district.





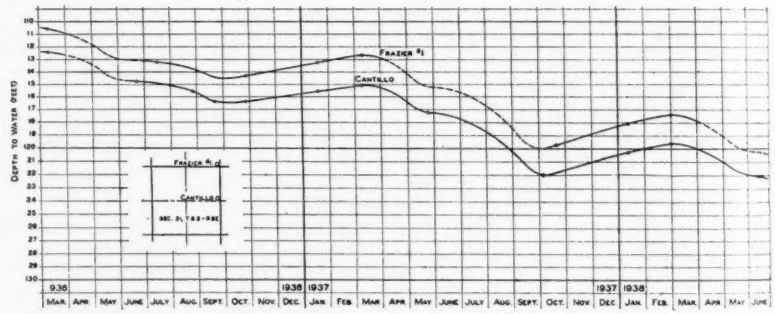


FIG. 1 (TOP) EXAMPLE OF SIMILARITY OF WATER LEVEL TRENDS IN USED AND UNUSED WELLS IN AN AREA OF GOOD LATERAL CIRCULATION. FIG. 2 (CENTER) WATER LEVELS IN USED AND UNUSED WELLS ONE-FOURTH MILE APART, SHOWING A SLIGHT LAG IN SUMMER BUT NONE IN WINTER. FIG. 3 (BOTTOM) IRRIGATION AND DOMESTIC WELLS ONE-HALF MILE APART, SHOWING CLOSELY CORRESPONDING WATER LEVEL CHANGES

For the 1937 season, with the pumping district much expanded, the composite draft of all the wells was 65,700 acre-feet and the volume of dewatered ground was 414,000 acre-feet.

Observations of the water table at the end of the pumping season, in October 1937, showed that the drop of the water table had been 12 to 15 ft in the neighborhood of many wells and was greater than 6 ft over an area of 28,000 acres. But the following March, when the doming had flattened, and with the natural recharge through the winter, the residual lowering for the 12-month period in the areas of heavy draft was 5 to 7 ft and the loss was more than 3 ft over an area of 65,000 acres.

The recharge in the Eloy basin is mostly lateral subsurface inflow and is a function of time. The largest inflow is through the narrows at Sasco, and is about three miles wide. The original groundwater contours of the basin exhibit a smooth fan. For the years 1936 and 1937, the recharge must have been practically the same. There were no large floods in the Santa Cruz River and the total stream flow was less than normal both years.

For the favorable conditions as described, an equation for each year can be written as follows: The volume unwatered times the specific yield plus the recharge to the district from without its boundaries equals the quantity of water pumped. In this equation, there are two unknown factors but by writing the equation separately for each of the two years, preferably widely dissimilar years, a solution is possible. Using S for specific yield and R for the annual recharge, the equations are:

$$(1936)\quad 170{,}000\,S + R = 38{,}000$$

$$(1937)\quad 414{,}000\,S + 356/365\,R = 65{,}700$$

The solution gives a specific *(Continued on page 398)*

Precooling Vegetables by Water Spray

By R. L. Perry

PRECOOLING of fruits and vegetables which are to be shipped with bunker icing has become well established within the past few years, for several reasons. The immediate lowering of temperature retards ripening and transpiration, and guards against decay; the subsequent refrigeration requirement is reduced because of less rapid respiration; and a saving in transit refrigeration costs may be secured under modified icing schedules.

In fruit precooling, rapid circulation of cold air has been most widely used, both in large warehouses and in portable field units. Although water-precooling of vegetables gave promising results in Florida fifteen years ago, as an outgrowth of celery washing, it has only recently been introduced into California. Experimental water-cooling of asparagus in the Sacramento-San Joaquin delta in 1933 led to commercial development in 1937. Meanwhile celery precooling with water had become established in southern California, and water-cooled celery and peas were shipped from the delta in 1937. However, cauliflower and broccoli gave discouraging results in the Santa Clara valley toward the end of 1937, probably because of abnormal field infection, excessive accumulation of bacteria and mold organisms in the recirculating water, and insufficiently low water temperatures. A very large portion of the 1938 asparagus shipments were water-cooled.

Leafy vegetables must arrive on the market fresh and firm, and free from decay. These two requirements are somewhat conflicting, for the high humidity which maintains freshness unfortunately favors the development of undesirable bacteria and molds. Freshness is promoted by water-cooling for, instead of the slight evaporation incidental to air cooling, there is a carry over and retention of about one pound of water per crate. Because of the possibility of spreading infection in the washer, and of the higher humidity in transit, it is essential that good performance in the precooling unit be obtained, and that temperatures be kept low in transit.

The design of a water-cooling unit is in accordance with the well-recognized general principles of refrigeration and heat transfer. There are, of course, many details to be perfected in the construction of a compact and economical unit of high capacity. One of the principal problems is in the arrangement of the method and amount of water circulation which is necessary to provide rapid heat transfer. Rapid transfer is essential in order to secure adequate cooling in a reasonable time, without requiring excessive size.

In order to bring the commodity below 40 F (degrees Fahrenheit) in 10 to 15 min, the water temperature must be below 36 F, preferably at or below 34 F. This requires ample cooling surface and high water velocities in the ice-melting tank or refrigerant evaporator.

If adequate agitation about the commodity could be secured with complete counterflow, the water-circulation rate would have to be only slightly greater than the commodity rate; the water would leave slightly colder than the commodity entered; and the water could be wasted after one passage through the unit. This would permit the use of fresh water, and would give the very definite advantage of washing with clean water. In practice, however, the crates of produce tend to carry water with them against the counterflow current, and insufficient removal and replacement of cold water between bunches or heads occurs. The circulation rate must be increased to the point where the advantages of counterflow are lost and cross flow may be more convenient.

Another consideration which might be used in arriving at a reasonable circulation rate is the maintenance of an adequate temperature difference between the commodity and the water. With an initial water temperature of 34 F, and a commodity temperature dropping from 76 to 40 F, the initial maximum temperature difference is 42 F, which is 7 times the final maximum difference of 6 F. Water rates of 2, 6, and 15 times the vegetable rate give temperature differences, assuming a specific heat of the vegetables of 0.9, of approximately 10, 16 and 17.5 F. The additional tem-

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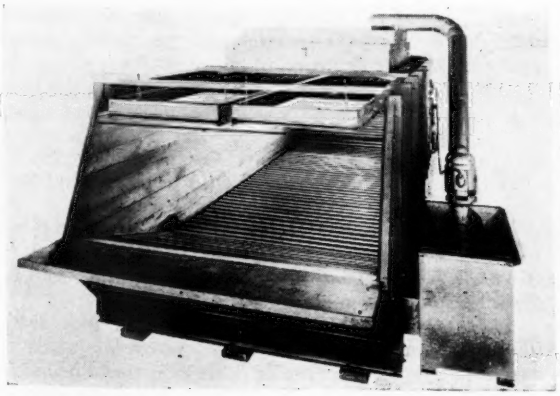
Author: Assistant professor of agricultural engineering, and assistant agricultural engineer in the agricultural experiment station, University of California. Mem. A.S.A.E.



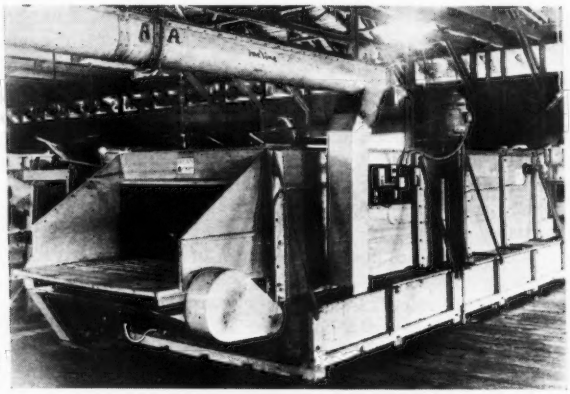


FIG. 1 (LEFT) HYDRO COOLER, PROVIDING PARTIAL SUBMERGENCE OF CRATE. FIG. 2 (RIGHT) PREFRIGERATOR, WITH CONVEYOR ABOVE TANK LEVEL FOR OVERHEAD FLOOD COOLING

perature difference gained by increasing the water ratio from 6 to 15 does not seem worth while. It would be more economical to build a longer unit and allow more cooling time if temperature difference were the only factor influencing the water rate.

In practice it has been found that the water rate which gives a reasonable temperature difference does not provide sufficient agitation for adequate heat transfer, in either of the two types of units which have been in use. In the first, the crates are partially submerged while they are carried through a tank on a conveyor, with some water spray or flood from above. In the other the conveyor is above the tank water level, and entire reliance is placed on the overhead flood. Water rates were raised to 70 gal per crate in the first, and as high as 330 gal per crate in the second. With asparagus, cooling rates ranging from 0.1 to 0.33 deg drop per minute per degree difference between commodity and water were obtained. The lower value was observed in early trials, before the unit was perfected, while the higher figure represents exceptionally favorable performance. With a rate of 0.3, the commodity can be brought from 76 to 40 F, with 34 F water, in 7 min, and to 36 F in 10 min. With a rate of 0.2, it will take 10 min to reach 40 F and 15 min to reach 36 F.

The refrigeration required is, of course, dependent on the temperature reduction of the commodity, the refrigeration losses from the unit, the pump energy input, the cooling of fresh water when the tank is initially filled, and the ice unavoidably remaining at the end of the day's run.

Ice required for cooling the tank initially is 1¼ lb per gal of 60 F water, or 1900 lb for a 1500-gal tank. For commodity cooling only, each 100 lb of produce cooled through 10 F requires 6.2 lb of ice. For maintaining a melting ice surface large enough to keep the water temperature at 34 F, a unit with a 1500-gal tank, handling 360 36-lb crates per hour, must have in it 1000 to 1500 lb of ice, which is largely unusable at the end of the day's run if the last crate is to be properly cooled. The ice meltage from a pump driven by a 5-hp motor is about 70 lb per hr. The refrigeration losses from this size of unit are equivalent to from 50 to 100 lb of ice per hr. Thus in a 6-hr run, cooling 3 cars of 608 crates, each weighing 36 lb through 40 F, the ice requirement would be about 20,000 lb, or 67 blocks. In practice the usage ranges from 5000 to 7000 lb per car.

In addition to the direct engineering problems of heat transfer, commodity and water movement, and construction, there are problems in the application of these units. One important factor is the possibility of spread of infection from diseased to healthy produce by the recirculating water. Obviously infected bunches, spears, or heads should, of course, be culled before going through the cooler. Although many of the types of organisms which may be carried into the water by vegetables may be of such a nature that they will not grow rapidly on vegetables at transit temperatures and humidities, it would seem desirable to keep the water as clean as practicable by prewashing the produce, and by continual addition of fresh water to dilute the dirt, suspended plant material, and organisms which otherwise unavoidably accumulate.

Excepting the poor appearance of crates and labels which resulted from the extreme wetting, the asparagus in seven water-cooled cars carefully examined on arrival in New York was in better condition as regards freedom from wilting, mold, and bacterial soft rot than four air-cooled cars shipped for comparison during the 1937 season. Although incipient decay was noted in a few spears in all cars, it was more pronounced in the air-cooled cars.

In the early part of the 1938 asparagus season, some fields were flooded and infection with a mold identified as a Phytophthera gave trouble in transit. Shipping tests were therefore directed toward the problem of infection in the washer, and its development enroute. Spears inoculated with bacterial soft rot, Fusarium and Phytophthera molds, showed little if any decay at the end of 7 days in transit at 42 F, more at 47 F for 10 days, and serious trouble in two days after arrival at room temperature. The asparagus cooled at the end of the day's run, when 2,000 crates had been cooled, showed more decay than that which went through the washer at the start of the run. These observations only emphasize the importance of reasonable sanitation mentioned above.

A preliminary test on new potatoes from Kern County to Chicago gave excellent control of decay and of browning of the unavoidably skinned areas. Although drying can be used to prevent development of bacterial soft rot, it may not be so effective in preventing discoloration. More trials will be required to establish the soundness of conclusions from the initial shipments.

Many of the units in the field are equipped with sterilamps in an effort to reduce the danger of infection. Total plate counts of bacteria, before and after using the lamps, have shown rather erratic results, and do not, of course, indicate whether the organisms killed are the ones responsible for the trouble. It is not thought that the time of exposure is long enough to control mold spores, although some non-spore-forming bacteria may be killed.

In conclusion it has been observed that (1) water-cooling units require only 10 to 16 min, as compared to 8 to 14 hr for portable air-cooling units; (2) the higher resultant humidities tend to favor freshness, and (3) reasonable sanitation must be practiced, if decay from contamination spread by dirty water, is to be avoided.

(ACKNOWLEDGMENT: The author wishes to acknowledge the assistance of the following who conducted several phases of this work: Dr. J. H. MacGillivray, truck crops division and Dr. P. A. Ark, plant pathology division, University of California; W. T. Pentzer, W. Barger, Dr. G. B. Ramsay, and Dr. J. S. Wiant, Bureau of Plant Industry, U. S. Department of Agriculture; and The American Fruit Growers, California Packing Corporation; Union Ice Company, Consumers Ice and Cold Storage Company of Sacramento, and John Bean Manufacturing Company, which were among the commercial agencies giving assistance.)

Simplified Determination of the Safe Yield of a Groundwater Basin

(Continued from page 396)

yield of 11.5 per cent and a recharge of 18,500 acre-feet, much less than was actually pumped from the wells. The difference between the recharge and the quantity pumped each year was the depletion of stored supply.

The quantity R is not the exact inflow into the basin; it is the quantity which could be pumped without any net March-to-March lowering of the water table. The relation of R to the inflow is not known. Continuous lowering year after year is undesirable, since it changes the lift and pump discharge and increases the cost of the water.

The occasional year of heavy rainfall and runoff may afford some additional recharge, but, for the most part, the effect will be seepage of water a few feet into the soil, and the subsequent loss of the water by evaporation.

No more wells should be drilled in the Eloy district for two reasons: first, by reason of the overdraft and the mutual interference, the day of exhaustion would be hastened for all wells; second, with the high lift and the assurance that new pumping plants can have only a limited usefulness, the economic prospect does not justify any more wells.

Control of Moisture and Temperature in Potato Storages

By A. D. Edgar

THE GENERAL purpose of this paper is to discuss a basis for the design and operation of common potato storages adapted to regions where the average winter temperature is from about 20 F downward; in this paper this will be called the northern area, to distinguish it from the southern area of warmer winter temperatures. The general storage problem in the northern area is to keep the potato temperature up and avoid damage to the structure and potatoes from condensed moisture; in the southern area the problem is to keep the potato temperature down and the air moisture content up. The present discussion applies only to the storage of late-crop potatoes in the northern area.

The purpose of the potato storage investigation, of which the present discussion is a part, is to work out storage designs and methods of control for potato storages which will provide optimum storage conditions as laid down by plant physiologists and adapt the storages to the climatic and handling conditions of the area under consideration. The work is being carried on cooperatively by the Bureaus of Agricultural Engineering and Plant Industry of the U. S. Department of Agriculture and by the state agricultural experiment stations of Maine and Michigan.

Early in the storage study, potato storage bulletins were reviewed. The authors of these bulletins were in general agreement as to the conditions under which potatoes should be stored for best results, but there was little agreement as to the methods and storages best adapted for meeting storage requirements. Points of general agreement in the storage of potatoes are: (1) Store mature, disease-free potatoes with a minimum of mechanical injury; (2) cure them about 10 days at about 50 F, after which they should be cooled to a holding temperature of 40 F for long-period storage; (3) keep the relative humidity of the storage above 85 per cent as long as it can be done without damaging the building or potatoes by condensed moisture. Starting with the above general requirements, we have been working towards the design of structures that would be economical, permanent, and easily managed.

The field studies have been carried out in the highly concentrated production area of Aroostook County, Maine, and in the more diversified production areas of Michigan. Potato shrinkage studies have been made upon large quantities of potatoes stored under conditions ranging from nearly optimum to very poor. Records have been made of all storage conditions, and the effect of separate storage factors have been evaluated. In the study, temperatures were determined at various points in the mass of the potatoes, in the walls and ceiling and under the floors by means of thermocouples; rate of air circulation in flues and in wall circulation spaces was determined by means of low-velocity anemometers developed by W. V. Hukill of the Bureau of Agricultural Engineering; temperatures and humidities were recorded by hygrothermographs and determined by sling, hand, and motor-aspirated psychrometers. During the observations we found almost ideal conditions being maintained both in model and in so-called impossible storages; also the poorest of storage conditions were being maintained in both good and poor storages.

In working upon the problems of storage design and construction both temperature and moisture control were considered. That is, in working out insulation values and in determining heating or ventilating requirements, temperature and moisture control must be considered as related factors.

As a result of the study, a wall circulation space was found to be the safest way to prevent freezing and the most practical method of insuring uniform temperature within the storage. However, condensation of moisture on the cold surface of the circulation space, as formerly constructed, resulted in decay of adjoining structural members, mainly at the base of the studding, joist ends, and the sills. Because of this decay, many warehousemen tried to keep the circulation air so dry that moisture would not condense in the wall space, but this resulted in additional attention to control, increased potato shrinkage, and fuel requirements. We are now working toward the design of potato storages that will take advantage of simplified and improved control by allowing condensation in the wall circulation space. To prevent damage by condensed moisture, the condensing surfaces are waterproofed and drain into gutters, in which water collects in cold spells and from which it evaporates in warm spells, giving some automatic moisture control. The air circulation space is placed inside the waterproofed condensing surface and entirely separated from the studding; at the lower end it terminates above the joist ends and sills, so no moisture is likely either to condense or drain onto any of the structural members. The ceiling is insulated sufficiently to prevent condensation of moisture and dripping on the potatoes below.

The basic principle followed in determining insulating values for walls and ceilings is to select such values as will result in balancing, as nearly as possible, the rates of loss of heat and moisture against the rates at which heat and moisture are given off by the stored potatoes, and thereby reduce to a minimum the attention required for either ventilation or artificial heating. Calculations are based on monthly averages, over the storage period, of the following factors:

1 Outside air—
Dry-bulb temperature, heat content, moisture content
2 Inside air—
Optimum dry-bulb temperature, heat content, moisture content
3 Rates of heat production in storage—
By respiration of potatoes
Released by cooling of potatoes
Artificial heat, when required

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, Pacific Grove, Calif., June 28, 1938.

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4 Rates of heat removal from storage—
  By conduction through walls and ceiling
  By ventilation, when required
5 Rates of moisture production in storage—
  By evaporation from potatoes
  By evaporation from moist walls, during warm spells
6 Rates of moisture removal from storage—
  By condensation on cold wall surfaces
  By ventilation, when required.

In working out the amount of insulation to be used and the provisions for ventilation, we make our balances by the trial-and-error method; the minimum amount of insulation is determined as follows:

1 For the ceiling, insulation must be adequate to permit desired storage humidity to be maintained without ceiling condensation, that is, sufficient ceiling insulation must be provided to keep the ceiling surface temperature above the dew point of the air below. Surface temperature of a dry ceiling is calculated, using a surface resistance factor of 0.6 F/Btu/ft²/h.

2 Inner surfaces of outside walls adjoined by wall circulation spaces to be waterproofed for protection from condensed moisture, sufficient insulation so that heat conducted through the wall will not condense more moisture from the circulating air than is expected to evaporate from the potatoes.

3 If minimum insulation, based upon moisture control, is so low that artificial heating becomes uneconomical, adjust insulation value upward toward maximum insulation value based upon moisture control.

The maximum insulation value based upon moisture control is that value which is exceeded when wall condensation and ventilation for temperature control together remove more moisture from the storage air than is expected to evaporate from the potatoes.

Provisions for ventilation are based upon the amount required to cool the potatoes from the initial curing temperature to the holding temperature, within two months following harvest.

SUMMARY

Summing up our observations we conclude as follows:

Temperature and moisture control in northern potato storages mainly by conduction of heat and condensation of moisture upon waterproofed surfaces is better than control mainly by ventilation, because

1 Better control is secured which results in reduced potato shrinkage.
2 Control is partly automatic, so requires less attention of the storage operator.
3 Less artificial heat is required. Condensation of moisture within the storage adds very little to conduction loss, but about 1,000 Btu of heat is lost with each pound of moisture removed by ventilation, in addition to conduction loss.

Temperature and moisture control by condensation would not seem applicable to the southern area, where conduction losses are low and emphasis must be placed upon the removal of heat.

No sharp division line can be drawn between the northern and the southern area, but in areas where the average winter temperature is 20 F, there will probably be little difference which system of storage control is used.

It is believed that the method of design outlined in this paper constitutes the first serious attempt to evolve a logical system of design of storage structures, which takes into account optimum conditions for storage of a given commodity, established climatic and engineering data, and having as its object the provision of a structure which under average seasonal conditions will automatically maintain as nearly uniform optimum storage temperatures and humidities as possible with a minimum attention being required during periods of considerable departure from seasonal norms, and a minimum total attention during the storage period.

AUTHOR'S NOTE: A more detailed description of this method of storage design will be found in the forthcoming USDA Technical Bulletin 615, "Potato Storage in Maine."

Contributions of Technology

I AM pleased to define a high standard of living as "having those things one is unhappy without." Progress, as we see it, comes from raising desires and attempting to meet those desires. And I believe, in talking to any thinking individual in this country, a man working in a factory or a man recently laid off, he will agree that we cannot consider retreating from our present standards, from the things it is possible to have in our everyday living.

No engineer can look without concern on a general restriction in all production. By no stretch of the imagination or by no complicated calculation can this practice benefit anyone. A system of free competition working under reasonable legislative control brought this nation further toward the goal of a universally high standard of living for everyone than has been reached in any other comparable nation. In no other nation, nor in this nation, has there been demonstrated that any other system can serve so well. In the desire to escape the consequences of the terrible unbalancing of world economy, caused by the great war, many people have embraced unproven ideas. We are learning, however, that the facts of the way of nature—that the facts of human behaviorism are greater than any unnatural plan or scheme, no matter how heavily subsidized. The engineer devotes his life to utilizing the facts of nature, directing them to the benefit of man.

The factory workers of 1899 each utilized 2.11 primary horsepower and worked 56.8 hours per week to produce the living standard of that period. The living standard of 1937, however, was produced by an increase of 81 per cent in the number of factory workers over 1899, an increase of 130 per cent in primary horsepower per worker, and a decrease of 30 per cent in hours per week. If the factory workers today employed the production technique of 1899, they would have to work 94 hours per week to produce theoretically our present standard of living. Or we may reduce to 23 the number of hours per week and with our present factory workers and methods of production again produce the living standard of 1899. In other words, if we had reduced the work week as fast as our ability to produce had increased starting with 1899, there would have been no rise in the standard of living.

From the contribution of L. J. Fletcher to the Public Forum sponsored by American Engineering Council, at Philadelphia, May 13, 1938.

Recommended Practice for Use of Sunlamps in Animal and Poultry Husbandry

By Lee Lloyd

THE primary purpose of this article is to make available data regarding methods of using sunlamps for poultry and livestock. The recommendations given are based on our experience with several hundred installations, put in after a careful study and analysis of basic research conducted by leading universities, to determine the advantages to be derived from the use of ultraviolet. It is hoped that our practical experiences will be helpful to those who act in an advisory capacity to farmers, particularly agricultural engineers, county agents, and utility salesmen who are working in the farm field.

It has long been known that natural sunlight benefits human beings, as well as birds and animals, in two ways. One is the biologically effective action on the ergosterol in the skin, creating in it vitamin D, which assists metabolism and the assimilation of calcium and phosphorus, resulting in better bone and tissue development and general improvement in health. The other effect is to assist in clearing up skin diseases, and in the healing of wounds. It is the former with which we are primarily concerned.

It is well known that the ultraviolet content of sunshine is the prime factor in securing each of these advantages. It is also known that the ultraviolet content of winter sunlight is very low, and that even in midsummer its intensity varies widely during different periods of the day, and from one day to another. On cloudy and rainy days, the ultraviolet may be only one quarter of what it is on a sunny day. On such days birds are likely to spend more time indoors, and there is practically no biologically effective ultraviolet transmitted through ordinary window glass.

Sunlamps have the great advantage of furnishing a practically constant amount of ultraviolet, regardless of the season of the year, the time of day, or the condition of the weather.

Where birds have been deprived of outdoor sunlight for considerable time, and have been in production, they frequently get into a rundown condition, which, according to a Kansas bulletin[2], may result in the following things: (1) Egg production is low; (2) eggs produced have very thin shells; (3) the whites and yolks have less calcium and phosphorus than normal eggs; (4) a much smaller percentage of these eggs hatch than normal eggs; (5) fully developed eggs are often retained in the oviduct for three or four days; (6) the hens often develop lameness or paralysis of the legs or wings; (7) the bones become low in their mineral content and are easily broken, and (8) the calcium and phosphorus content of the blood is below normal. Continuing, the bulletin states "That ultraviolet light will prevent the above condition is shown by the experiment which we conducted last winter."

We have been using two types of sunlamps. One, known as the 450-watt, type S-1 is a powerful source of ultraviolet. Equipped with an aluminum reflector, the ultraviolet intensity of this unit at a distance of 30 in is approximately three times that of the best midsummer noonday sunlight on a clear day. The other source is known as the 500-watt mazda CX lamp, which, with an aluminum reflector, has an ultraviolet intensity of about one per cent of the intensity of an S-1 lamp.

Experience has shown that a very short exposure to an S-1 would be adequate provided the radiation fell directly on the legs and comb of the bird. Practically it is much simpler and surer to use longer exposures which, together with the extended hours of lighting now common practice in poultry husbandry, makes the CX lamp an almost ideal source to use for poultry.

Experience has shown that the best results are obtained where the daily length of the period of irradiation is varied, depending upon the nature of the birds' confinement, the stage of their production, and the length of time they have been confined.

For example, when hens are first brought indoors from the range on which they have been running all summer, they are already accustomed and sensitized to sunshine and its ultraviolet. Therefore, if sunlamps are placed over them immediately when they are brought into the house in the autumn, there is no sudden break in their habits, but simply a continuation of those sunshine values brought indoors to them. On the other hand, if hens have been housed from 45 to 60 days, a little extra caution has proved to be desirable.

Naturally everyone wants his flock of hens to be profitable, and if they have started to drop in egg production after three or four months of confinement, we have found an inclination to "rush in" with sunlamps. We have found it desirable to curb this inclination. It appears important to be even more cautious and take even more time to sensi-

INTRODUCTION

The fact that ultraviolet radiation of birds and animals results in certain definite benefits has been well established by research work at various universities. Proving that sunlamps can be used profitably by the farmer, however, is a thing that requires the analysis of many installations over a period of years. When several hundred farmers purchase sunlamps and continue to use them year after year, it is reasonably good evidence that they find their use profitable.

The author of this article has been specializing on the sale of sunlamps to farmers for several years. Naturally he has collected a lot of practical data on ways and means of securing the best results from his product, and on methods of use and things to be avoided. He employs a trained veterinarian, and together they have developed a technique which has resulted in tripling the number of sunlamp installations each year for the past two years. Both Mr. Lloyd and his consulting veterinarian, Dr. C. C. Pink, have addressed meetings of the American Society of Agricultural Engineers. Those who heard them were thoroughly convinced that they know whereof they speak. It is fortunate that they are willing and have taken the time to summarize their experiences as a guide to others.

L. C. PORTER[1]

Author: President, Lee Lloyd and Associates, Inc. Assoc. A.S.A.E.

[1]Illuminating engineer, General Electric Co. Fellow A.S.A.E.

[2]Kansas State College, Science Vol. 60, No. 1563, pp. 549-550.

TABLE 1. RECOMMENDED PRACTICE IN THE USE OF ULTRAVIOLET FOR POULTRY

(CX lamps mounted 3 ft, and S-1 lamps 5 ft, above chicks or mash hopper in all cases.)

Period and birds per lamp	Daily exposure time for each lamp type		
For baby chicks (Start irradiation the day the chicks are placed in the brooder.)	250-watt CX	500-watt CX	S-1
1st week	4 hr	2 hr	30 min
Thereafter	8 "	4 "	1 hr

For birds just brought in from all-summer outdoor range			
Birds per lamp	80	100	125
1st week	2 hr	30 min	5 min
2nd week	2 "	45 "	10 "
3rd week	4 "	1 hr	15 "
4th week	6 "	2 "	30 "
5th week		3 "	45 "
Thereafter	8 "	4 "	1 hr

For birds housed 45 to 60 days without irradiation			
Birds per lamp	80	100	125
1st week	1 hr	30 min	8 min
2nd week	2 "	45 "	10 "
3rd week	4 "	1 hr	15 "
4th week	6 "	2 "	30 "
5th week		3 "	45 "
Thereafter	8 "	4 "	1 hr

For birds housed 3 months or more without irradiation			
Birds per lamp	80	100	125
1st week	1 hr	30 min	8 min
2nd week	2 "	30 "	15 "
3rd week	3 "	1 hr	20 "
4th week	4 "	1 "	30 "
5th week	5 "	2 "	40 "
6th week	6 "	3 "	50 "
Thereafter	8 "	4 "	1 hr

NOTE: The advice of a veterinarian should be obtained before starting irradiation of sick flocks.

tize the hens to indoor "sunshine" than where the period of confinement has been of shorter duration. We have found it desirable to start slowly and carefully, in spite of the fact that it will take longer to bring them back into high production.

Gradual introduction of the sunlamps has frequently been followed by a continued drop in production. In these particular experiments, the hens were all being fed cod liver oil. Eventually the sunlamp pens came back in a manner highly satisfactory. Real trouble is generally experienced where we do not have comparable pens, to prove to the user that the sunlamp pens do not drop as low as those without the sunlamps.

Where baby chicks are to be irradiated, a minimum of caution has been found necessary. We have had instances where users have burned a 250-watt CX lamp 24 hr per day, reporting complete and almost surprising satisfaction.

We have found that a great many flock owners become especially interested in sunlamps when their flocks are sick. Sometimes we are not told by them that their flocks are sick. That is one reason the Milwaukee Electric Railway & Light Company has employed a veterinarian skilled in poultry ailments and requirements. He inspects flocks shortly after an installation is made, and endeavors to correct any conditions which might operate against satisfactory results from the use of the sunlamps. Our constant task is to impress purchasers again and again with the fact that ultraviolet simply makes it possible for poultry to absorb the maximum value from the minerals in the food provided them, and is to a large extent a counterpart of sunshine; that if poultry is suffering from ailments which good natural sunshine would remedy, then they can expect proper use of sunlamps to help them; but that if their poultry is suffering from ailments which natural outdoor sunshine will not remedy, sunlamps may help them, but certainly will not cure them.

For instance, we have had cases where the flock dropped in production, and investigation has disclosed that the hens were covered with mites and lice. When these were removed, the hens again began to lay better. The sunlamp could not remove the mites and lice. We have had instances where chicken pox was in full swing and the owner frankly told us he was getting the sunlamps to cure them, without knowing what ailed them. The use of a veterinarian has paid the lighting company many times over in actual revenue, as well as in good will.

Table 1 summarizes the practice which we have found produces the best results under the various conditions mentioned above.

Some Turkey Experiments. The irradiation of turkeys and turkey poults has been under way in a more or less experimental manner under the supervision of Dr. C. C. Pink for approximately four years in Wisconsin, as a result of two conditions in this area which seem to be causing considerable trouble. The first was a high percentage of unfertile eggs with consequent poor hatchability, and the second was a condition where the turkey poults have seemed to require extra encouragement in order to get them to eat. It may be interesting to note brief summaries of some of his reports:

"A short test was run near Whitewater, Wisconsin, where turkey hens showed lack of color and condition, and were not in fit shape to produce fertile eggs and thrifty poults. Two groups of twenty-five turkey hens each, from range, were put in confinement, one under a 500-watt CX sunlamp. After two weeks the one group began to show color, the eggs increased in fertility from 35 to nearly 70 per cent, and losses due to general debilitated conditions were stopped."

"In an experiment this spring at the Rosengren Turkey Farm, the following conditions had prevailed in previous years. The windows in the brooder room face the south, and it was noticed that the poults in the south brooders would advance much more rapidly than those on the north side of the building. The light seemed to encourage the young poults to come out and eat. Using a regular light bulb helped to a certain extent, but the results were still discouraging. Then a 250-watt CX sunlamp was suspended between two pens, irradiating the feeders of each, at a distance of 30 in. Another sunlamp was covered with purple cellophane and suspended in the same manner, to note the difference in value by eliminating the infrared and some of the visible rays in the one test.

"The results favored the use of the sunlamp without using cellophane, as this seemed to be more favorable in promoting better weight and growth.

"Feeding conditions were helped very much in the one using the uncovered sunlamp. The poults did not respond as readily under the sunlamp covered with cellophane."

"Another test was made on 3000 turkey poults at Johnson's Creek, Wisconsin, employing 500-watt CX sunlamps. This was on one of two groups of poults shipped from Minnesota and one of the two Wisconsin-hatched groups. At the time of the installation, the Minnesota poults showed a weakened and rachitic condition while the Wisconsin poults were much healthier. It was evident that the weak condition of the Minnesota birds demanded special care.

Sunlamps in this case were suspended 4 ft above feeders, irradiation started at 15 min twice daily, and gradually increased to 4 hr per day. The sunlamp was then lowered to 3 ft and irradiation cut to 2 hr for 3 days and then again advanced to 4 hr.

"At the end of two weeks, the irradiated poults had gained remarkedly over the other group and were in much better condition, although at the time of installation, this was the poorer group of the two. There were no new cases of slipped tendons and the average weight was over one-half pound more. The control group had grown visibly weaker and a number of birds could barely stand on their feet. On account of the apparent loss, it was decided to irradiate this group also and the sunlamp was moved from one pen to the other. Although losses were checked, this group of poults did not catch up to the other of irradiated poults before being turned out on range."

The CX type of sunlamp, with its mild ultraviolet output and long required time of irradiation, has seemed in these tests to perform a double duty, in furnishing adequate irradiation to take the place of outdoor sunshine, and at the same time encouraging the birds to eat.

Pigs Show Quick Results. One of the newest lines of use for ultraviolet lamps here has been in the irradiation of pigs. In this particular use of sunlamps, there seems to have been a double value obtained from the lamp, more outstanding than has been noted in other usages.

The combined effect of ultraviolet and penetrating infrared rays available in the CX lamps have brought most favorable reaction from users and highly interesting results. The infrared playing over the baby pigs during early March and other bad spring days, has made them contented under the lamp instead of cuddling close to the mother for warmth, only to be in many instances rolled upon and killed.

In addition to the infrared values however, users report a growth and weight that has been highly profitable to them. For instance, the particular breed and past experiences of one user had caused him to anticipate approximately a 6-mo period to bring his pigs to 200-lb weight. However, this is the third season this user has taken advantage of sunlamps for his spring farrowed pigs, and consistently he has produced approximately 200-lb pigs a month earlier and in doing so has topped the market for price. Undoubtedly he has saved something in feeding, but no record has been kept on that item.

We have had one instance where rickets had developed to a point where pigs could no longer stand. They quickly improved under the sunlamp and the comments of this owner would indicate that he will always hereafter use sunlamps over his pigs.

We have found a great many of those who bought their sunlamps for hens, moving them from place to place, particularly over their pigs, but in some cases even taking them into the house and using them themselves.

We find some users burning the 250-watt CX lamps 24 hr per day with a view to obtaining as much infrared as possible, with consistently satisfactory results.

Use on Calves Gradually Increasing. More and more regard for utraviolet lamps for use over calves is being noticed. More veterinarians are becoming interested in them where they encounter pneumonia in calves or cows. To meet this condition and interest, a new manner of hanging the lamps has been devised so as to focus the lamps on each side of the cow in such a manner that the lung areas are well covered. The response has caused veterinarians to express gratifying astonishment. The 500-watt CX lamps have been used in these cases.

Without doubt this is another instance where the combination of ultraviolet and infrared is rendering value, with special emphasis on the high penetration of the infrared available in the CX type lamps.

All in all, the cautious and well-guided use of ultraviolet for poultry and livestock seems to be developing rather rapidly of its own accord, and it may well prove to be a great contribution to the field of poultry and animal husbandry.

Time-Saving Value of Good Lighting

THE Committee felt that it would be of considerable value to obtain data on the time-saving value of good lighting on the farm. A search of the literature disclosed plenty of data regarding office and industrial lighting.

Unfortunately no similar studies seem to have been conducted on farms. It seems probable that where a farmer can move about a well-lighted farm and turn on the lights ahead of him, instead of stumbling around with one hand occupied in carrying an oil lantern, considerable valuable time must necessarily be saved. And the same holds true for the farmer's wife in the home. We did find one study[1] that had been conducted at Ohio State University, showing the time spent filling and cleaning oil lamps on 13 farms. These farms had an average of 6.08 lamps cleaned and filled per week, which took on the average 28.8 min of a woman's time.

One of the Committee members, Mr. Gorham, ran the following questionnaire in "Electricity On the Farm": "In doing the daily chores how much time have you found it saved with electric lights over the kerosene lantern way? Old way—hours. Electric way—hours." The data from 922 replies received from 40 different states shows an average of 3.4 hours per day to do the chores by oil light, versus an average of 1.9 hours per day to do them under electric lights. This is a saving of 1.5 hours per day. In a year's time, excluding summer, that amounts to approximately 400 hours, or an entire month's working time. The economic value of a man's working time for a month far exceeds the difference in cost between poor oil lighting and good electric lighting. The comments that accompanied the replies were most interesting. In many cases they indicated how much electricity had broadened the farmer's life and made it pleasanter and easier, and relieved him from worry of fire.

Of course, these data are just estimates, but probably the average of 922 farmers is not far off.

However, we had hoped to make some actual stop-watch time studies to check the farmers' estimates. None of the Committee found an opportunity to do that. It was suggested that such studies might be good projects for some of the Smith-Hughes teachers to carry out in their rural electrification courses. Mr. Blauser discussed this with some of the Ohio people, and found them interested. It is hoped that some actual studies can be started early next fall.

Obviously another advantage of good lighting on the farm is the reduction of the accident hazard as well as reduction of the fire risk.

From a report of the A.S.A.E. Committee on Uses of Electric Light in Agriculture, 1938.

[1]Thesis, Some Effects of Rural Electrification upon the Standard of Living of 13 Farm Families, by Margaret W. C. Black, Ohio State University, 1927.

Temperature of Soil Heating Cable in Three Different Media

By John E. Nicholas

THE RAPID transfer of heat from the source to the parts to be heated depends largely on the conductivity of the media surrounding the heating element.

Electric soil-heating cables used in hotbeds for early plant propagation are generally placed at 4 or 6-in depth in the growing soil. The thermal conductivity of dry soil[1] is approximately unity, and when wet it has a conductivity of 10. It is apparent that heat transfer from the cable through the soil will be slow in any direction, and a large quantity of soil must be warmed in a standard 6x6-ft frame or any multiple of this length.

Usually a standard hotbed frame is well banked with straw, manure, and earth, or a combination of any of these which are easily available. This minimizes the heat losses through the wood of the frame. The sash conserves the heat within the frame; the solar radiant energy whenever it is available enters through it.

Placing the heating cable on top of the growing soil, we eliminate the necessity of heating large quantities of soil, and the possibility of plant freezing is eliminated.

The layer of air between the soil and sash has a small heat capacity, cools quickly to the lower limit of the thermostat setting, and the heating operation therefore begins before any damage is done.

It has been shown experimentally[2] that plant growth between and by the side of electric soil-heating cable which is placed on top of the bed is as satisfactory as other methods of heating, in the results of which work it is stated: "Plants near the cable were visibly larger than those between the cables, indicating that the highest soil temperature (nearest the cable) stimulated plant growth and that the apparent drying of the soil near the cable was not detrimental to plant growth."

The temperature of a standard 60-ft length cable, made with No. 19 nickel-chrome, lead-sheathed wire, having a connected load of 400 w on 110 a-c voltage was investigated. A 6x6-ft standard frame was divided into four equal parts. Two parts were filled with growing soil. One part each with sand and peat moss. The cable was laid to a depth of 4 in, arranged as shown and marked in the accompanying figure. The depth of each material in its respective partition was 6 in.

Thermocouples were attached to the surface of the cable at points X, Y, and Z, in sand, soil, and peat moss respectively. The remote bulb of the thermostat was placed between two runs of cable in the soil partition, one-half of it projecting into the air, the other buried in the soil. The growing soil used was obtained from the college vegetable gardens. The sand was regular greenhouse sand and the peat moss was a portion from a new bale just purchased.

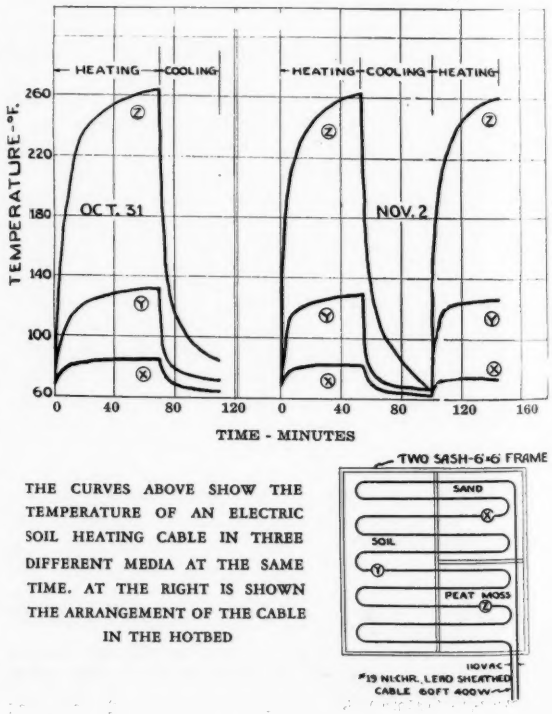
The heating was brought to equilibrium under the thermostatic control, after which the heating and cooling cycles became automatic.

The temperature of the same cable taken simultaneously in three different media during a heating and cooling cycle is shown as of October 31. The cycling continued. A heating, cooling, and a heating operation is again shown as obtained two days later on November 2. It was determined experimentally that the temperature in the peat moss, ½ in away from the cable, was 90 F when the cable was 265 F.

From the figure it is apparent that the sand is the best heat conductor and gives the most uniform heat distribution. The cable temperature 4 in in the soil reached 130 to 132 F. But the same cable placed on top of the soil seldom exceeded 100 F.

In using electric cable for early plant propagation, this investigation implies that probably a mixture of half and half growing soil and sand might be tried for uniform heating.

A cable placed on top of the growing soil eliminates the use of drainage provision and the regularly recommended use of insulation for the bottom of the bed. It simplifies the use of the heating cable and the cost of operation is reduced. It might be suggested that with the use of a pronged cultivating tool during any cultivation which may be necessary, the cable will not be injured.



THE CURVES ABOVE SHOW THE TEMPERATURE OF AN ELECTRIC SOIL HEATING CABLE IN THREE DIFFERENT MEDIA AT THE SAME TIME. AT THE RIGHT IS SHOWN THE ARRANGEMENT OF THE CABLE IN THE HOTBED

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Author: Professor of agricultural engineering, The Pennsylvania State College. (Mem. A.S.A.E.)

[1]Thermal conductivity of soil increases with the percentage of moisture. The per cent of moisture in this study was, for soil, 14.0 per cent; for sand, 15.1 per cent. Peat moss was dry as received, moisture not determined.

[2]Stout, G. J., and Nicholas, J. E.; Mack, W. B., and Sprague, D. C., "Methods of Heating Hotbeds," Bulletin 338, Pennsylvania Agricultural Experiment Station.

Analysis of Agricultural Engineering Research

By E. A. Silver

RESEARCH represents one of the three great areas of agricultural engineering activity. During the past year the A.S.A.E. Committee on Research considered as its master objective, progress in research, which of course implies both qualitative and quantitative progress. No one who understands the possibilities of real quality research, can conscientiously say that at the present time we have enough research.

Is it not true that quantity in research should be looked upon as the result of quality? If that is true, our endeavors should be directed first of all toward improvement in the quality of our research, before we can very aggressively appeal for increased quantity. In other words, the amount of research may take care of itself somewhat automatically, if we will first put our house in better order from the standpoint of quality. This does not mean that we have no responsibilities for increasing quantity, but these responsibilities can be better expressed after we have attempted to meet our obligations in regard to quality.

WHAT IS RESEARCH?

Before we can go much further in this discussion, it is necessary to reach a common understanding on what research is. Many of us want to look upon it as a purposeful act for gain, as an investment in thinking, energy, money, and time for dividends. One of its many definitions is: "Research is determining the cause of a defect." Some of us would probably want to carry this definition out further and include the correction of the cause of the defect, as well as the determination of specifications for corrective measures. That, of course, depends a great deal on what we demand from a definition. The word "defect" as it is usually defined applies to material things or to workmanship. In this case it must be defined in its broader sense, indicating that something falls short of perfection or idealism.

An ordinary writing desk may be entirely correct and without defect for the present time, but immediately a new desk is built which has features incorporated in it to make it more applicable for its purpose, it is evident that the old desk was defective.

Research is largely a thought process, and what we do in research is to adapt old experiences to new situations. Another definition which brings out the thought process says that research is "an organized and systematic procedure of creating new relationships of old experiences, mentally, and of synthesizing new experiences and manipulating both until the proper relationships are found to solve a problem." According to this definition, research can be carried on entirely within the thinking of individuals. However, the intellectual capacity of the average individual is such that it requires the assistance of experiment.

Experimentation. A problem requiring solution involves something new, something which we do not have at present. This might, however, be only a new combination of old experiences, and we may solve it entirely within our own thinking. The solution to the problem, however, may involve some new experiences. We see the general direction of our deficiency, and in the absence of facts we formulate theories. Experiment is an event or a succession of events in a research process, whereby an artificial environment is set up to prove one or more theories. Quoting from "The Search for Truth" by E. T. Bell, "Theory and experiment are the two crutches on which science hobbles forward; theories point out new paths; experiments determine if they are blind alleys or short cuts to good highways."

Development. Development work alone is not research, but it may be an important part of a research process. It implies manipulation and is associated with the interpretation and application of a principle, law, element, method, plan, or means resulting from fundamental research.

Testing. We hear many times that testing, as we know it, is not research. If we had the mental capacity to solve all problems with our thinking, it would not be necessary to apply manipulative skills in order to get results. The only reason that we do testing is because of our low mental capacity, and we are compelled to do it in order to check our theories.

Testing is the means or medium of proving the validity of a thought. It borders closely on method, and is a function of experiment. Suppose that during a research process a bearing in a gasoline engine continually burns out. Various theories are formed in regard to the cause. Is it not true that our thinking is first given opportunity for a solution? If such a solution is not forthcoming, and we are not sure of the validity of the solution, we immediately set up an experiment or a series of experiments in an artificial environment in order to check these theories. The results of these experiments may be obtained in several different ways, and to the means of checking these results we may very well apply the word "testing".

AREAS OF RESEARCH ACTIVITY

1 *Area of Discovery.* This may include the discovery of a principle, fact, law, element, or method, and includes the disclosing of sufficient proof to transpose the theorem into an established truth. Some people say that research is aimed only at discovery of new facts, but inasmuch as some principles are evolved from facts, we must admit that a collection of facts may be a step or a means or a part of a research process aimed at a discovery of a new principle. Much of the work in determining the cause of a defect lies in this area.

2 *Area of Interpretation and Application.* This is the area wherein the discovery is interpreted in terms of application and is used, applied, and recognized in life's relationships.

By "improved quality" of research we do not mean research of greater significance, on the basis of worth or value in terms of returns from the investment, in each of the two areas stated above. We often hear it said that a certain individual is full of ideas, but that he cannot comprehend the application or production angle of the problem. He is labeled as impractical. Another man may lack the necessary qualifications to visualize and apprehend these ideas or theories so necessary in research activity.

A situation such as this is commonly found in industry,

Presented before the Committee on Research round table at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 27, 1938.

Author: Research agricultural engineer, Ohio State University, and chairman, A.S.A.E. Committee on Research. (Mem. A.S.A.E.)

with one man capable of working in the area of discovery, and the second man in the area of interpretation and application. This does not mean that men working in either of these two areas are not good research men. Little progress can be made, however, if these men are compelled to work independently of one another. If they work cooperatively, excellent results can be obtained by having one man bring forth the theories or ideas, and the other interpret and apply them.

Many authorities say that the object of fundamental research is to obtain facts and principles without regard to their application. Yet before these facts and principles become useful to mankind, it is necessary to interpret and apply them. True basic or fundamental research lies in the area of discovery, and it is this area in which public service institutions should center most of their research activities. Give industry some basic fundamental facts, and it will soon apply them.

SOME DEFICIENCIES WHICH RETARD PROGRESS IN RESEARCH

1 Lack of understanding of what research is, its divisions of activities, and the relations between them

2 Shortcomings of research workers

- (a) Lack of ability to detect and select problems of far-reaching fundamental significance
- (b) Lack of ability of research workers to break down a problem and segregate it into its various lines of endeavor
- (c) Lack of ability, and inclination to tackle a problem without following a definite analysis of it
- (d) Tendency to tackle the more simple problems, rather than the fundamental, far-reaching types
- (e) Lack of training in research methods, or too little contact with procedures
- (f) Lack of determination to carry through to a final solution the essential constituents of a research project

3 Failure to give due consideration to regional or national problems to avoid duplication of effort

4 Resident teaching and extension forces engaged in research only as subordinate to their activities

5 Lack of coordination between industry, public service institutions, and the public

6 Narrow-mindedness that permits departmental, individual, and institutional jealousies.

Today there is entirely too much scratching at the surface of a problem, instead of tackling the roots or fundamentals, largely due to lack of ability to reach those fundamentals through an analytic procedure. Public service institutions cannot expect to compete with industry in the developmental phase of a problem, but they can furnish industry with fundamental facts and principles which are so pertinent to a development program. One of the greatest assets to research is the ability of the research worker to analyze thoroughly the problem at hand. As research workers in our profession, we have no excuse to foster any haphazard methods in the pursuance of research activity.

Since research is primarily a mental process, we must be able to think constructively. Idle fancies, trivial recollections, or flitting impressions will not satisfy the demand. Each thought or idea must have a sequence as well as a consequence, a consecutive ordering in such a way that each determines the next as its proper outcome, while each in turn leans back on its predecessors. These successive thoughts or ideas grow out of one another. They do not come and go in a medley, but each phase is a step from something to something.

A few of the requisites for a successful research worker are (1) natural vision and power of imagination, (2) natural ability to recognize a problem, (3) open-mindedness and tolerance, (4) keen observation, (5) eager curiosity, (6) ability to differentiate between essentials and non-essentials, (7) firm determination against all pitfalls in research, (8) habit of approaching a problem systematically, and (9) ability to cooperate with others.

Research cannot exist without a problem. If we have the proper type of man for research, the importance of the problem factor is lessened. Nevertheless, something should be done to direct attention toward improvement of the choice of problems for research. When formulating our research programs, consideration should first be given to those problems of ranking importance; their various phases thoroughly analyzed to determine the proper line of attack and without undue duplication of effort by the various experiment stations.

Some of our most prominent industrial research organizations classify their research as follows:

1 *Fundamental Research.* This applies to research of a basic fundamental nature, which lies within the area of discovery previously mentioned. It may include the discovery of a principle, law, element, method, or fact, and is at the bottom of all development work.

2 *Development Research.* This type of research applies to the development of the discoveries made in fundamental research.

3 *Service Research.* This research applies to the tracing of any defects, their causes, and attempts to correct them after the principle, element, method, or fact has been put into practical application.

During the past few years our research activity has been centered largely on either the development or service research, with very few studies rating as fundamental. In order to improve the quality of our research, it will be necessary to concentrate more of our activity towards those problems which would fall within the area of discovery or fundamental research.

There is no other field of activity in which cooperation or coordination is so imperative. Research is done by groups of minds and every group must function as a unit. There is no place for petty institutional or departmental jealousies or selfishness.

A research project of the fundamental type may involve many fields of endeavor. Therefore, there should be no sharp dividing lines to prohibit a well-knit, organized effort. In this respect stronger relationships must be established between industry and the experiment stations, and between agricultural engineering departments in different states.

It is hoped this presentation will give a clearer picture of the field of research in relation to its various components. We who are working in this field must have a common understanding of what we are doing so that we will be talking in the same plane, in order to classify our activities properly and to facilitate the exchange of ideas.

Is it not true that our profession will be measured in a large way by our actual accomplishments in research—accomplishments of the greatest benefit to mankind? We cannot, nor do we want to, keep people from researching. But certainly a profession which is responsible for research ought to do something about raising the standards thereof. As long as research workers strive to improve themselves, so will research improve.

What Agricultural Engineers Are Doing

FROM THE U. S. BUREAU OF AGRICULTURAL ENGINEERING

AT THE water conservation conference held at Salt Lake City, Utah, July 19, under the auspices of the Utah Section, American Society of Civil Engineers, Harry F. Blaney, as chairman of the A.S.C.E. irrigation division committee on conservation of water, presented a paper on the objectives and activities of that committee, together with a report of its accomplishments. A. T. Mitchelson presented a paper on "Conservation of Water by Recharge of the Underground Supply."

* * *

J. C. Marr inspected work being carried on by the Bureau in cooperation with the Idaho agricultural experiment station to determine the effect of pumping from wells on ground water level, and ascertaining the efficiency with which the water is pumped. A system of observation wells was installed for this purpose and the depth of water in them was measured at regular intervals. At present a line of levels tying in all of these observation wells is being run. Several of the pumping plants, of which there are approximately twelve, are being tested each week for efficiency.

* * *

Observations made by R. A. Work of pear tree transpiration during an extended period of above-normal temperatures at Medford, Oregon, (with daily maxima ranging from 100 to 107.3 F) indicated an extraordinarily high rate of transpiration. Measurements of fruit temperatures showed that fruit on dry trees, which had been shaded for 2 hr before measurement, averaged at the core nearly 9 F warmer than fruits on well-irrigated trees. Some fruits on dry trees had core temperatures of 117 F (air temperature 104 F). Severe sunburning of Anjou pears occurred throughout the week, even on well-irrigated plots.

* * *

Carl Rohwer surveyed the site for the dam to be constructed on the Southern Great Plains Experiment Station of the Bureau of Plant Industry, at Woodward, Okla. He also inspected the work of stripping the site, excavating the cutoff trench, and building sheet piling. Levels were run for setting slope stakes, and additional levels for determining the amount of material removed in the stripping of the site.

* * *

Harry F. Blaney, Colin A. Taylor, and Dean W. Bloodgood, in company with officials of the Los Angeles water department, visited the San Fernando Valley, Calif., for the purpose of inspecting sites for proposed duty of water investigations to be carried on by the Bureau in cooperation with the Los Angeles water department. It was decided that Mr. Taylor would supervise experiments on use of water by citrus, Mr. Bloodgood the experiments on field, vegetable, and miscellaneous crops, while Mr. Blaney will have general supervision of the entire project.

* * *

Several orchards in the vicinity of Glendora, Fullerton, and Covina, Calif., were furrowed by the furrowing machine for laying out broad, shallow irrigation furrows in citrus and walnut orchards in tests conducted by Colin A. Taylor. Irrigators have found it much easier to handle the water on fairly flat grades by the use of broad furrows. Some experiments are being carried on to adapt this type of furrow to hill land. After the practical matter of making the broad furrows under a variety of orchard conditions has been worked out, it is planned to make a series of absorption and penetration tests on various soil types.

* * *

According to R. L. Parshall, tests are now being made of the use of cotton fabric treated with special tar oils for lining irrigation ditches to prevent seepage. It is planned to provide a model lined ditch section for the purpose of showing the method of preparation of the ditch surface and application of the tar and cotton fabric. The model will be about 6 ft long and 3 ft wide, and will weigh possibly 300 lb. It will be on exhibit at the Fort Collins, Colo., hydraulics laboratory.

* * *

Colin A. Taylor and John O. Reeve are conducting some tests in North Pomona, Calif., based on the discovery made by Dr. Wendt of the California Institute of Technology, that vitamin B1 is helpful in starting small plants. One of the problems with the older citrus orchards is that of starting new trees when occasional replanting is necessary, as the young trees are often wilted badly because their roots are not well enough established to carry through a regular irrigation interval. The experiments referred to are being made on seedling and year-old orange trees, which are treated with a B1 solution before planting.

* * *

M. R. Lewis and Dean C. Muckel continued the investigation of irrigation possibilities in North and South Dakota, including inspection of dams and spillways recently constructed by government and other agencies. Mr. Lewis was impressed with the improvement in the quality of the work being done on WPA dams in South Dakota as compared with that done prior to 1937. Many individual farms were visited and the possibilities of irrigation studied.

* * *

E. M. Dieffenbach, in charge of the weed control machinery project and Dr. R. J. Evans, state agronomist for Utah, recently made a trip together through the Unitah Basin in eastern Utah, and into Carbon and Emery Counties in Utah. Numerous plots were visited which were being cultivated at regular intervals for weed control. The chief weeds being fought in the counties visited were wild morning glory *(Convolvulus arvensis)* and white top *(Lepidium draba)*.

* * *

The work on the cooperative sugar beet production machinery project at Davis, Calif., is being extended with the funds donated for this project to the University of California by the U. S. Beet Sugar Association. Mr. McBirney reports that the work at Davis, as heretofore, will be carried on cooperatively between the division of mechanical equipment of the Bureau of Agricultural Engineering and the division of agricultural engineering of the University of California, and will be jointly directed by S. W. McBirney of the Bureau and Roy Bainer of the University of California. The agricultural engineering division of the University has added to its staff Col. O. B. Zimmerman as research associate, John B. Powers, as research assistant, Fred Lory, Jr. as machinist, and Percy E. Symens as mechanic's assistant, who will devote their entire time to the project. Others of the regular staff will spend part of their time on the project. Mechanical harvesting will receive chief attention at present, though the ultimate aim will be the reduction of both spring and fall labor peaks of sugar beet production.

* * *

W. H. Redit assisted in the transplanting operations of a cooperative fertilizer-placement experiment with cauliflower on August 3 at the Long Island Vegetable Research Farm, Riverhead, New York. One of the primary objects of the study is to compare the placement of fertilizer in a band at each side of the row with the common farm practice of broadcasting the fertilizer.

* * *

E. D. Gordon reports that during the past month the farm machinery laboratory has been visited by several groups. The 4H Club boys who were in Auburn for their summer gathering came over in groups of about 50 on two different days. During Farmer's Week the work that is being done at Auburn was explained and a demonstration of the equipment in operation was made to about 100 farmers. On August 9 about 125 agronomists and soil specialists of the Southeast section stopped for a brief visit at the tillage laboratory which was part of the tour they were making of experiment station projects.

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

FROM THE C.R.E.A.

Dr. E. A. White, director, and *J. P. Schaenzer,* assistant director, Committee on the Relation of Electricity to Agriculture, are scheduled to appear on the program to be presented at the Vienna Section of the World Power Conference to be held at Vienna, Germany, from August 25 to September 2, 1938. The title of their paper is "Trends and Tendencies in Farm Power in the United States." Dr. White and Mr. Schaenzer will also present a paper entitled "Power Resources on the Farms of the United States" before the Seventh International Management Congress in Washington, D. C. Sept. 19-23.

NEWS

North Atlantic Section Program Announced

FOUR general sessions, three concurrent round table sessions, the annual dinner, two optional field trips, and a wide choice of entertainment for ladies are featured in the program for the yearly meeting of the North Atlantic Section of the American Society of Agricultural Engineers to be held September 20, 21, and 22, at Boston. Headquarters of the meeting will be at the Parker House, home of the famous roll by the same name.

L. G. Heimpel will preside at the opening general session, Tuesday afternoon, September 20. N. D. Herrick, chairman of the local arrangements committee will explain the attractions and points of interest available in the city and vicinity.

"What Is an Agricultural Engineer" is the subject of an address by H. W. Riley, chairman of the Section. Advance information classifies it as a thoughtful evaluation of the profession, with suggestions for the future. On the technical side this session will feature "Selling Kilowatts on the Farm," by M. H. Lloyd; "Farmstead Engineering for One-Story Barns," by W. C. Harrington; and "Light on the Farm of Tomorrow," by Miss Lillian Eddy.

Round table sessions Tuesday evening will center around power and machinery, rural electrification, and farm structures.

Discussion starters in the power and machinery group, A. A. Stone presiding, will be short papers on "Progress in the Design of Rotary Tillage Implements," by C. W. Kelsey; "Corn Planter Fertilizer Attachments for Heavy Rates of Application," by M. G. Huber; "Repairing Farm Machinery," by B. A. Jennings; "Adapting Tractors for High Compression Fuels," by Frank Stablein; and "The Method and Effect of Deep Tillage," by G. D. Jones.

"Rural Electrification Needs" will be the central theme of discussion in the rural electric group. F. M. Wigsten will preside. "Ideas," by George W. Kable; "Research and Development," by W. T. Ackerman; and "Salesmanship," by J. H. Bodwell are the priming talks listed.

The farm structures men, with H. E. Pinches presiding, will build their discussion on the following foundation papers: "Silo Pressures and Temperatures with Grass Silage," by J. R. McCalmont; "Condensation in Walls of Refrigerated Storages," by L. L. Sammet; and "Warm Air Ventilation for Animal Shelters," by P. S. Martin.

Combined structures and electrification interest are featured in two papers of the morning session Wednesday, September 21, namely, "Refrigerated Locker Storages," by A. A. Geiger, and "Wall Construction for Air Conditioned Homes and for Refrigerated Storages," by W. V. Hukill.

"Putting Photography to Work," by J. W. Gillon of the Eastman Kodak Co., another paper of the same session, will feature engineering uses of cameras. W. C. Krueger will preside at this session.

"Grass Silage" developments are to be reported up to date by Frank Hamlin in the Wednesday afternoon session in charge of J. S. Webb.

Some new data on engineering in crop production will be presented by G. A. Cumings in a paper on "Putting Fertilizer Where It Belongs."

"White Man Farming (Continued)" by H. E. Babcock, Jr., follows up a popular contribution to last year's program by the senior Mr. Babcock.

H. W. Riley, toastmaster for the annual dinner, will present a program featuring an address entitled "Looking Forward", by S. P. Lyle, president of the A.S.A.E.

Thursday morning L. F. Livingston will direct the closing technical program, in which consideration will be given to "The Low Cost Automotive Type Tractor," by F. J. Zink; "The Binder or the Combine—Which?" by A. G. Heidrich; and "Electric Fence Controllers," by H. W. Riley and Sidney Krasik.

Luncheon Thursday noon will be at Henry Ford's Wayside Inn. It will be followed by two optional tours, one to inspect interesting and practical rural electric applications, and the other to the historic points in and about Sudbury, Concord, and Lexington.

The ladies, in addition to participating in the annual dinner, the luncheon, and the Thursday afternoon historical tour, will have numerous opportunities to walk, or ride in private cars, to see historic and interesting sights such as Charleston Navy Yard, Harvard's glass flowers, Bunker Hill, and the Boston Fish Pier. There will also be a three-hour deep sea sail as guests of the ladies of the local arrangements committee.

To Receive Nominations for 1939 A.S.A.E. Medal Awards

IN ACCORD with the rules governing the award of the Cyrus Hall McCormick and John Deere Medals, the Jury of Awards of the American Society of Agricultural Engineers announces that it is open to receive nominations of candidates for these awards for the year 1939. A.S.A.E. members nominating candidates for either medal are asked to keep in mind the purpose of the medal, and to base their nominations thereon.

As inscribed thereon, the McCormick Medal is awarded "For Exceptional and Meritorious Engineering Achievement in Agriculture." This is interpreted to mean the total achievement of a continuing career or to any single item of engineering achievement, and to apply equally to all special fields and types of engineering in agriculture.

On the Deere Medal the words "For Distinguished Achievement in the Application of Science and Art to the Soil," are interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being susceptible to "evaluation by the engineering criteria of practicality and economic advantage."

The Jury of Awards has specially requested that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor.

Each nomination must be accompanied by a statement of reasons for nominating the candidate, and of the qualifications of the nominee, including his training, experience, contributions in the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

Additional opportunity to present to the Jury individual views on the fitness of any nominee for either award will be provided during the fall meeting of the Society at Chicago. No new nominations can be received at that time, however. The Jury will accept and consider nominations received on or before November 1.

Nominations should be addressed directly to the chairman of the Jury of Awards—Leonard J. Fletcher, Caterpillar Tractor Co., Peoria, Ill. It is requested also that seven copies of supporting information for each nominee be furnished, one for each member of the Jury.

Additional information on the history, significance, and description of these medals is available in the issues of AGRICULTURAL ENGINEERING for May 1932 (McCormick Medal) and October 1937 (Deere Medal).

Washington News Letter

FROM AMERICAN ENGINEERING COUNCIL

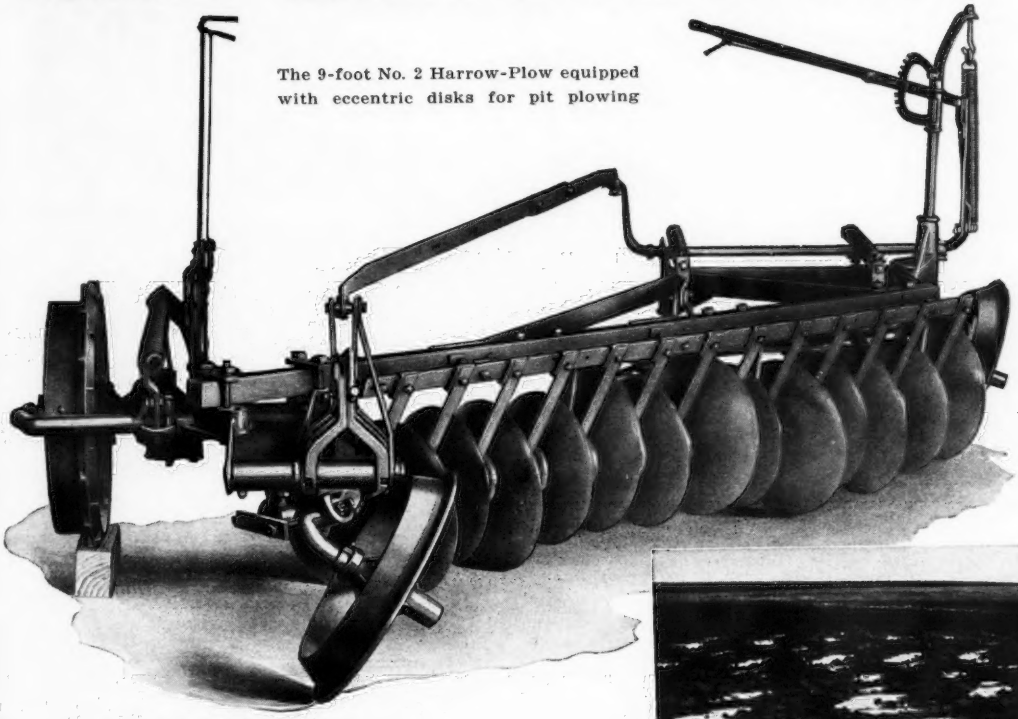
THE PROGRAM FOR A WORLD CONGRESS ON MANAGEMENT

AS ANNOUNCED in earlier issues of the Bulletin, the Seventh International Management Congress will open in Washington on September 19 and continue through the week.

Some 250 delegates of management councils from 16 different nations will assemble for the opening session at eleven o'clock in the Chamber of Commerce of the United States on Monday, September 19. More than 500 advance registrations from American delegates have already been received. The registration fee of $10.00 includes the cost of six volumes of more than 200 papers on management which will be distributed to all registrants prior to the Congress. These volumes constitute a library on the significance of management and will serve as a basis for discussion at six simultaneous technical sessions. These discussions will be assembled in a final seventh volume at the end of the Congress, which will be sent to all those registered.

The general sessions highlight the broader accomplishments of management both in its relation to the *(Continued on page 410)*

A New Way to Save Soil and Moisture



The 9-foot No. 2 Harrow-Plow equipped with eccentric disks for pit plowing

The *"Pit Plow"* . . .
INTERNATIONAL HARVESTER'S
New Moisture Conservation Aid

International Harvester has pioneered another important development in soil and moisture conservation . . . the new McCormick-Deering Eccentric-Disk Harrow-Plow. This new "pit plow" leaves the soil full of small basins or pits that catch and hold moisture as well as retard wind erosion. The "pit plow" and the recently developed McCormick-Deering Basin Lister give the farmer in the dry sections of the west and southwest two top-notch moisture conserving aids.

The plow has eccentric or off-center disks interspaced with smaller disks. The off-center disks are arranged spirally on the gang bolt so that the long side of each successive disk is a quarter turn farther around on the gang bolt. These large eccentric disks cut about three inches deeper than the smaller ones, leaving the soil pitted. The spiral arrangement leaves the pits in diagonal lines—uniformly distributed.

A feature of this equipment is that farmers need not purchase a complete new disk if they already have a McCormick-Deering Harrow-Plow. A combination of eccentric disks, substituted for the regular ones, will do the job.

Full information about this new soil conservation aid will be supplied on request.

A pit-plowed field immediately after a hail storm (precipitation .72 of an inch). Note capacity of pits to hold water

Basin listing is another method of combatting soil erosion and conserving moisture. A McCormick-Deering Basin Lister is shown building dams in lister furrows at intervals of 10 feet to form basins which catch and hold rainfall

INTERNATIONAL HARVESTER COMPANY
(INCORPORATED)
180 North Michigan Avenue Chicago, Illinois

McCORMICK-DEERING

Washington News Letter

(Continued from page 408)

American business system and to the public welfare. Subjects include: Management's Responsibility to Society, A Common Ground for Labor and Management, The Influence of Technical Progress on Social Development, and The Social and Economic Aspects of Employment. Speakers include: William Allen White, W. J. Cameron, John G. Winant, Karl T. Compton, A. W. Robertson, and Ralph E. Flanders.

The American Engineering Council is one of the twenty-five sponsoring organizations for this great Congress which is under the general direction of the International Committee on Scientific Management with the detailed management of the Congress in the hands of the American Coordinating Committee which represents the National Management Council as host to the Congress.

Inquiries regarding the Congress should be addressed to Nathaniel W. Barnes, Executive Secretary, 347 Madison Avenue, Room 1201, New York City.

The following is from a preliminary bulletin of the Congress: "The comprehensive program of activities announced herein has resulted from months of planning by many leading executives of American business organizations to develop the two official themes of the Congress—recent developments in management and economic and social aspects of management.

"In this triennial meeting of world experts in the field of management, the leaders of the Congress believe that there is afforded the finest opportunity in a decade for the consideration of those fundamental problems which should be the main concern of management—its opportunities, responsibilities, relationships, techniques, and practices.

"Membership in the Congress is open to anyone interested in the problems of management, upon the payment of a registration fee of $10. This fee entitles the member to receive the complete proceedings of the Congress and to participate in all its sessions. Supplementary family memberships may be obtained at $5 each.

"More than two hundred papers on a wide range of subjects relating to administration, production, distribution, personnel, agriculture, and the home have been printed in six volumes and will be distributed to all registrants prior to the Congress. These papers will serve as the basis for discussion at the simultaneous technical sessions. They will not be read at the sessions. Therefore, early registration is urged so that these volumes can be shipped at once and thus give each registrant time to study the papers before coming to Washington.

"At the general sessions of the Congress a feature will be the presentation of both American and foreign points of view on the most important aspects of management in relation to social and economic problems. All of the addresses made at the general sessions, as well as summaries of the discussion at technical sessions, will be printed in a final seventh volume to be distributed to registrants after the Congress.

"To all those who believe in the advancement of management—who recognize in the Congress an unusual opportunity to achieve a new understanding of management and to effect an exchange of experience on the part of alert minds from many countries—the Seventh International Management Congress cordially extends an invitation to attend and to participate in these meetings."

EDITOR'S NOTE: Dr. E. A. White will serve as "Rapporteur" of an Agricultural Section session on "Labor Resources and Their Use on the Land." Wheeler McMillen is chairman of another session on "Economic and Social Factors in Agriculture."

Program subjects of particular agricultural engineering interest include "Application of power farm equipment to intensified land maintenance for plowing under soil conservation crops," "Development of new uses for farm products not only for foods but for industrial raw materials and as a source of future fuels," "Sanitation in the housing of livestock," "The increasing availability of power resources to the farm and its effects upon farm operation," "Economic ratio between the use of animal and motor traction," and "Tenant-farmer and owner farm housing problems—extent and types of repairs and construction."

GEOGRAPHICAL DISTRIBUTION OF A.S.A.E. MEMBERS IN THE UNITED STATES, BASED ON THE A.S.A.E. DIRECTORY FOR 1937. CONTRIBUTED BY ARNOLD P. YERKES

R. W. Trullinger Advanced

AGRICULTURAL engineers will be interested in learning of the well-earned advancement of R. W. Trullinger, who was recently appointed assistant chief of the Office of Experiment Stations, U. S. Department of Agriculture. Mr. Trullinger's duties will be concerned with the work of the Office pertaining to the administration of federal-grant funds for agricultural research in the states, territories, and Porto Rico, as authorized by the Hatch, Adams, Purnell, and Bankhead-Jones Acts, and supplementary acts, and will include advice and assistance to stations in matters of organization, policy, conduct of work, personnel, and relationships. He will also have administrative oversight of "Experiment Station Record", the monthly journal of the Office which presents current agricultural research literature in abstract form.

Mr. Trullinger is a past-president of the American Society of Agricultural Engineers, and since 1921 has conducted the section, entitled "Agricultural Engineering Digest", which has been a regular monthly feature of AGRICULTURAL ENGINEERING.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the August issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Richard M. Babcock, assistant agricultural engineer (camp superintendent CCC), Soil Conservation Service, U. S. Department of Agriculture. (Mail) Madison, Nebr.

P. E. Benson, farm cost accountant, Minnesota Valley Canning Co., Le Sueur, Minn. (Mail) 103 N. Second St.

Daniel P. Heigele, sales training course, J. I. Case Co., Racine, Wis. (Mail) 1216 12th St.

Donald M. Kinch, department of roads and irrigation, State of Nebraska. (Mail) RFD No. 2, Cozad, Nebr.

L. Q. Lambert, student assistant to agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Belmont, Miss.

Geo. S. Messinger, vice-president in charge of engineering and production, Messinger Mfg. Co., Tatamy, Pa. (Mail) Box 37.

Earl A. Olson, dealer and rural sales manager, Idaho Power Co. (Mail) 912 N. 18th St., Boise, Idaho.

James B. Putman, assistant agricultural engineer and camp superintendent, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 1231 S. 14th St., Lincoln, Nebr.

Jerry Regmund, Kostoryz Gin Co., Corpus Christi, Tex. (Mail) RFD No. 1, Box 150-A.

C. M. Sanford, International Harvester Co. (Mail) Acorn, Va.

James H. Smith, salesman, J. I. Case Co. (Mail) 523 Y.M.C.A., Syracuse, N. Y.

Norton S. Stangeland, student trainee, J. I. Case Co. (Mail) Fillmore, N. D.

TRANSFER OF GRADE

W. W. Hair, Jr., assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 81, Garland, Tex. (Assoc. Mem. to Mem.)

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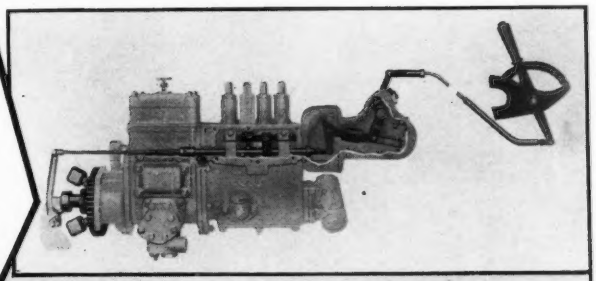

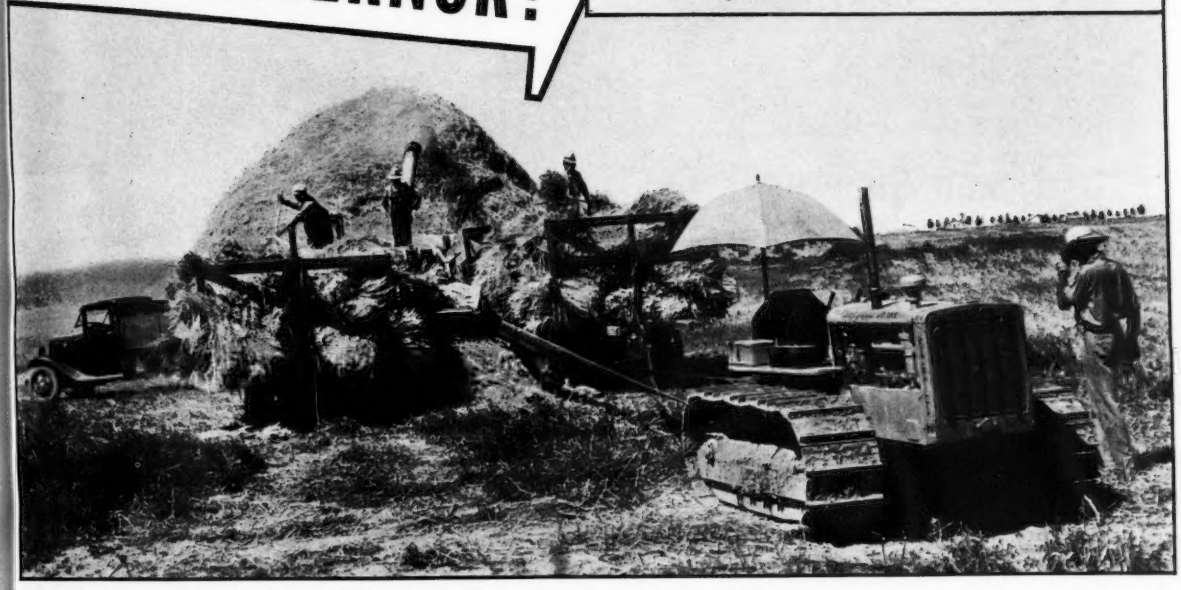

Threshing 2300 bushels of oats in 10 hours on 22 gallons of Diesel fuel.

Teamed with steady high compression and track-type traction to enforce unusual fuel economy, is the "Caterpillar" Diesel's governor.

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This governing helps make "Caterpillar" Diesel Engines remarkably responsive—to idle smoothly or to pick up and pull variable loads without fuel waste, "galloping" or stalling.

Such governing also helps explain why the "Caterpillar" Diesel Engine operates without a smoky exhaust—a factor that can assume real importance in the annual fuel and upkeep cost!

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Have you up-to-date answers to these questions?

EVERY year more farm families are turning to their agricultural leaders for advice on the increasingly important subject of farm electrification. So rapid have been the improvements in this field that General Electric has recently revised 18 of its 31 rural-electrification bulletins in order to provide farm people with up-to-date answers to their many questions and problems. You will find it convenient to have these new publications on hand when your farm families ask for the latest information.

If you're planning rural-electrification meetings, you'll want to use General Electric's popular talking picture, "Bill Howard, RFD," or one of the four new sound slide films on farm wiring, lighting, refrigeration, and electricity and plant growth. Use the coupon below to order the bulletins or to ask about using the movie and slide films. If you have special questions, just write Agricultural Leaders Rural Electrification Service, General Electric Company, Schenectady, New York.

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Please send, without charge, one copy of each bulletin checked:

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- ☐ Cost of Electricity, GEA-2244
- ☐ Rural-electrification History, GES-1612
- ☐ Farm Motors, GED-664
- ☐ Refrigeration on the Farm, 320-1106
- ☐ Electricity and Plant Growth, GEA-1644
- ☐ Milk Coolers, 320-2053
- ☐ Portable Farm Motor, GEA-192
- ☐ Electric Equipment (home), GES-1291
- ☐ National Electric Code, 51-735
- ☐ Conditioned Air, 420-1555A
- ☐ Milk and Cream Cooling, 420-15553
- ☐ Poultry and Eggs, 420-1555C
- ☐ Farm-killed Meats, 420-1555D
- ☐ Fruit Storage, 420-1555E
- ☐ Truck Farming, 420-1555F
- ☐ Please tell me how I can obtain, free of charge, your movie and slide films for use in my work.
- ☐ Will you please keep me posted on the latest developments in the field of farm electrification?

Name..... *Address*.....

521-37

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Tough, long-wearing Nickel alloy steels permit light weight with safety. Modern design obviates breakage, keeps upkeep down by using fine-grained Nickel alloy steels which can be uniformly heat treated and accurately machined. Your consultation regarding the uses of Nickel in original and replacement parts is invited.

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MODEL B PART	SAE STEEL
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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief,
Office of Experiment Stations, U. S. Department of Agriculture.

INVESTIGATION OF SUMMER COOLING IN THE WARM-AIR HEATING RESEARCH RESIDENCE, *A. P. Kratz, M. K. Fahnestock, and S. Konzo.* Ill. Engin. Expt. Sta. Bul. 290 (1937), pp. 140, figs. 39. This bulletin contains the results obtained during three summer seasons. Tests on cooling with ice showed that the ducts and registers of a central forced-air heating system can be successfully adapted as a distributing system for cooled air in the summertime without material alterations. There is no tendency for a pool of cold air to collect near the floor if the temperature of the air entering the room through the registers is not lower than 60 F. Baseboard registers can be used without objectionable drafts resulting if the velocity of the air at the register face is below 300 ft per min, although wall registers located 7 ft above the floor are preferable to baseboard registers with perforated grills. A two-story building of the type of the research residence may require the equivalent of 2 tons of ice in 24 hr, including the basement load, on days when the maximum outdoor temperature reaches 100 F, if an effective temperature of approximately 73 F is maintained indoors. An effective temperature somewhat higher than 73 F may be satisfactory for residence service, and in thise case more conservative results for the cooling load can be obtained. The use of awnings at all windows on east, south, and west exposures may result in savings of from 20 to 30 per cent in the required cooling load. The cooling load per degree difference in temperature is not constant, but increases as the outdoor temperature increases. The heat lag of the building complicates the estimation of the cooling load under any specified conditions, and makes such estimates based on the usual methods of computation of doubtful value.

It was found that the circulation of air from the outdoors at night, when used as a supplement to artificial cooling during the day, has considerable merit in reducing the seasonal cooling load that would otherwise be required. The circulation of air from the outdoors at night may make the use of artificial cooling unnecessary for a considerable portion of the summer season. The practice of partly opening a few windows at night is not very effective as a means of circulating air from the outdoors. The use of a fan in a forced-air heating system to circulate from 6 to 9 air changes per hour from the outdoors at night is much more effective than opening a few windows, even when the same amount of window opening is retained for the two cases. The use of a fan in a forced-air heating system to circulate 9 air changes per hour is more effective if all of the windows and the attic door or hatchway are opened than if only a few windows are opened. The most effective method of circulating air from the outdoors at night is to open all of the windows and to use a fan drawing the equivalent of approximately 17 air changes per hour into the windows of the first and second stories and discharging the air into the attic to escape from the attic windows. Satisfactory cooling with outdoor air at night probably cannot be accomplished by employing less than 9 air changes per hour. The gain arising from the use of more than 30 air changes per hour is very small. There is some advantage in opening the windows at 6 p.m. rather than 9 p.m., even if the outdoor temperature is slightly higher than the indoor temperature at 6 p.m.

In tests on cooling with mechanical refrigeration it was found that an indoor temperature of approximately 80 F with relative humidity below 55 per cent results in satisfactory comfort conditions in the living quarters of a residence. For complete comfort in sleeping quarters a somewhat lower temperature is desirable. The introduction of approximately one air change per hour of outdoor air, for the purpose of ventilation, is sufficient to prevent objectionable odors. A mechanical refrigeration unit capable of producing 2½ tons of refrigeration is sufficient to maintain conditions of comfort on two stories of a residence similar to the research residence when the outdoor temperature does not exceed 103 F and an amount of outdoor air equivalent to one air change per hour is used for the purpose of ventilation. The cooling load during the daytime can be reduced by supplementing artificial cooling during the day with cooling by means of outdoor air circulated at night.

Tests on room cooling units showed that such units should be operated and controlled to maintain constant dry-bulb temperature in the room rather than to maintain a complex schedule of indoor temperatures varying with the outdoor temperature. A room cooling unit of 300 lb ice capacity and having a melting rate of approximately 20 lb of ice per hour would be adequate to satisfy the normal cooling requirements of a medium-sized first-story room of a residence for most summer days, if no outdoor air other than that which enters by natural infiltration is introduced for ventilation. However, if the occupancy of the room is to be more than two persons it is essential that additional capacity be supplied for the necessary ventilation required to reduce undesirable odors.

The initial ice melting rate, or the melting rate during the first hour after the unit was started, was nearly twice as great as the normal melting rate. Of the total amount of heat absorbed by the room cooling units, approximately from 16 to 38 per cent was absorbed in the dehumidification process. In addition to the lowering of the dry-bulb temperature, the relative humidity of the air in the rooms was, in most cases, reduced about 15 points after three or more hours of continuous operation of the units. Although not centrally located on the first story of the residence, the cooling units operated in the living room effectively cooled and dehumidified the air in the adjoining rooms, and there was some indication that the reduction in relative humidity extended to the second story.

MOVEMENT OF MOISTURE IN SOIL, *M. R. Lewis.* Oreg. State Hort. Soc. Ann. Rpt., 28 (1936), pp. 164-171. The author, an irrigation engineer of the Oregon Experiment Station and the U.S.D.A. Bureau of Agricultural Engineering considers the relationship of the plant to soil and soil water as "one of dynamics, that is of moving bodies and changing forces. Water is continually moving from the moist soil to and into the roots and through the plant to the leaves where it is evaporated." He finds that "water will not move by capillary action more than a few inches at a rate fast enough to be of any importance to tree or nut growth; second, that infiltration into the soil may sometimes be very slow and may be very different in different parts of the same grove. Both of these findings mean that the grower needs to study moisture conditions in his soil. A great deal can be learned by the use of a soil auger or a shovel and simple examination of the soil. More can be done by systematic sampling and moisture determination."

FERTILITY LOSSES FROM HIGH PLAINS SOILS DUE TO WIND EROSION, *W. H. Langham.* [Oklahoma] Panhandle Sta., Panhandle Bul. 63 (1937), pp. 15, figs. 2. Analyses of successive annual dust deposits in attics of abandoned houses have shown that "from the first period of erosion, which occurred in 1933, through that of 1937, the organic matter and nitrogen had decreased 22.6 and 20.3 per cent, respectively. These results and a consideration of the literature suggested the following indications:

"(1) Fertility losses were heaviest the first 2 yr of erosion and are approaching a minimum. (2) The plant nutrient losses over this area as a whole are not as heavy as is indicated by public opinion, and the effect on fertility alone, especially if minimized by conservation practices, would not limit agricultural recovery for several years, even though the present adverse conditions continued. (3) Over the area as a whole the organic matter and nitrogen content of the undrifted cropped surface soils has been changed very little as a result of wind erosion. The principal damage to fertility constitutents has occurred in the drifting soils and in individual cases, such as very susceptible shallow soils. (4) The drifting soils, over a 10 or 12-yr period of present adverse conditions, would approach an organic matter and a nitrogen level approximately 70 per cent of that of the cultivated soils or 60 per cent of that of the virgin surface (before serious wind erosion began) and at which continued losses in these constituents would be almost a minimum."

PROGRESS IN THE ADOPTION OF SELECTED EROSION CONTROL PRACTICES, COON CREEK AREA, WISCONSIN (1933-1936), *M. H. Cohee and J. C. Jensen.* U. S. Dept. Agr., Soil Conserv. Serv., 1937, SCS-RB-5, pp. [1] + 37, pl. 1. The results of this survey are presented and discussed.